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## The Month.

THE CHARING CROSS DISASTER.—By the finding of the coroner's jury, and the admirably lucid evidence given by Sir John Wolfe Barry, Sir Benjamin Baker, Mr. Percy Tempest, and other witnesses, the cause of the accident at Charing Cross is now definitely revealed. Sir John Wolfe Barry, who acted as resident engineer during the building of the station, was able to give details concerning the manufacture and testing of the roof trusses and their subsequent erection. He stated that there was an enormous flaw in the tie-rod that was sufficient reason for the accident, and expressed the opinion that as Sir John Hawkshaw was a very careful man, the testing of all the tie-rods would be one of the things that would be certain to occur to him, and that an ostensible flaw would never have been passed before the roof was put together. Sir Benjamin Baker gave evidence at great length as to the condition of the broken tie-rod and of the ironwork generally. He could not say whether the flaw was due to an imperfect scarf weld, or to a defective weld in the original manufacture of the round bar. It really is not very important to know which of the two kinds of defect was to blame, as neither form of weld is now employed in the members of iron and steel structures. Sir Benjamin Baker added, that flaws were a recognised danger in roofs of this kind, a consideration that had induced him to advise the rebuilding of the roof as it was impossible to know whether other flaws existed. It is a most fortunate circumstance that no other of the many roofs whose safety depends upon single tie-rods have been known to fail in the same way; but as it took more than forty years to develop the Charing Cross fault there is no guarantee that some of the earlier roofs with welded joints will not fail in process of time. If the practice of employing duplicate tie-rods had been generally adopted, as it was by one or two of the earliest designers of wrought iron roofs, there would be far greater reason for satisfaction than now exists.

As to the general condition of the ironwork at Charing Cross, Sir Benjamin Baker was of opinion that the roof had lost only about 6 per cent. of its strength by corrosion. Mr. Percy Tempest adduced evidence showing very clearly the careful attention given to the maintenance of the roof since his appointment as chief engineer to the South Eastern and Chatham Railway in 1899. Before that date the ironwork had been thoroughly renovated, and after it various repairs had been executed. In December, 1902, the district engineer reported the roof to be in generally good condition, particularly the principals, and in July last year the work of renovation

was again undertaken. Examination of the broken end of the tie-bar led Mr. Tempest to the conclusion that no indication of the flaw could have been observed from the outside of the bar, an opinion which is amply confirmed by the evidence of Sir John Wolfe Barry and Sir Benjamin Baker. This being the case, we fully endorse the verdict of the coroner's jury that the accident was due to "an unforeseen flaw," and that no blame is to be attributed to the company's officials.

In view of the facts made so clear by this inquiry, all the morals and warnings which have been drawn from the occurrence and published so freely in the daily press fall wide of the mark. There is no general lesson to be derived from the accident that applies to modern engineering practice, and the only caution it suggests is that all early roofs whose safety depends upon single tie-rods of old fashioned wrought-iron, should be reinforced by additional tension members of suitable form so as to make sure no more accidents shall be caused by "unforeseen flaws."

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VENTILATION OF THE BAKER STREET AND WATERLOO RAILWAY.—As we have pointed out on previous occasions nothing could be less satisfactory than the ventilation of the Central London Railway. The engineers believed that the type of construction there adopted would permit the trains to eject foul air and so make room for the admission of fresh air in sufficient volumes. If the tunnels had been completely separate such a result might have been achieved, but it is difficult to understand how anything of the kind could have been expected when the tunnels were joined by openings at the stations and other points. The fact is that the openings facilitate the establishment of an underground circulation and the propulsive power of the trains does not materially improve the character of the atmosphere in the tunnels. The unsatisfactory conditions which soon developed on the line led to the installation of a large fan at the mouth of the tunnel at Shepherd's Bush so that the air might be sucked out between that point and the Bank, and in order to accomplish this result it is necessary to close the entrances to the tunnels at all intermediate stations. By means of this apparatus the air can be changed once a day, but as the fan can only be used effectively during the night when traffic has ceased, benefit is only experienced in the early hours of the morning. The public will derive ultimate advantage from the experience gained on the Central London Railway for it is certain that careful attention will be given to the question of ventilation in connection with all new lines of the kind. After carefully considering all possible alternatives, Mr. J. R. Chapman, the chief engineer of the Underground Railway Companies, has adopted a scheme for the Baker Street and Waterloo line under which air will be admitted into each station tunnel by way of the lift and staircase shafts and removed by an exhaust fan through a duct situated at a sufficient distance from the inlet. In this way constant and positive circuits of fresh air will be established along limited lengths of the line, and as the trains run into each circuit they will push horizontal columns of the fresh air into the tunnels, and so it is hoped that the atmosphere of the latter will be prevented from becoming very bad. By creating a downward current of air through the station shafts, the lift and staircase entrances will not greet intending passengers with the richly aromatic odour with which we are now familiar, and by withdrawing foul air from the top of the tunnels any smoke that may arise from unforeseen causes will be effectively carried away. The arrangement proposed is of limited character, being virtually a scheme of station ventilation although it is hoped that the air of the tunnels will derive incidental benefit. The scheme is certainly better than anything previously attempted but it can only be a makeshift, because the railway was not designed suitably for perfect ventilation for the establishment of which absolutely separate tunnels and access shafts constitute the essential basis.

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THE WEAR OF TRAMWAY RAILS.—In a recently published report Mr. Fell, the chief officer of tramways to the London County Council, states the general impressions derived from his visit to the United States for the purpose of inquiring into the working of tramways in that country. Among other subjects discussed that of the wear of tramway rails is one of the most important. Mr. Fell finds that in the United States, tramway rails have to be replaced long before they are worn out, because the upper surface rapidly assumes a waved or corrugated contour under the influence of traffic. The same tendency is also evidenced on British tramways, but the question has not generally received so much consideration as it deserves. At low speeds the corrugations have a wave length ranging from $2\frac{1}{2}$ in. to 5 in., and their character varies according to circumstances. They are

more pronounced on curves, being short on the outer rail and long on the inner rail, and the length of wave increases with the speed. The trouble is one that does not occur on lines where horse traction prevails, but is very serious on electrically operated tramways, and up to the present time no acceptable theory as to its cause has been propounded, and no certain means for its prevention has been found. It is quite evident that the character of the track foundation has little or no effect upon the corrugation of rails, because these appear to suffer equally in this country where the track construction is most substantial, and in the United States where it is very poor. Mr. Fell seems to think that the rails are turned out from the rolling mill with a slightly waved surface, which is exaggerated by the action of traffic. This idea is highly improbable, and as a matter of fact, some tests made by Mr. Fell have not revealed the presence of any such initial undulation. One interesting experiment made by him on part of a badly corrugated track, was to grind off the wave points by means of carborundum blocks fixed to a water-tank car, and it is worthy of note that the waves have not since re-appeared on these particular rails. Mr. Fell's opinion is that the upper surfaces of all tramway rails should be ground perfectly true and smooth before being laid, the idea being that this treatment would prevent the formation of waves or corrugations. It is not improbable that the corrugation of tramway rails may be due to oscillation of the vehicles, a view that finds some support in the general relation between wave length and speed. The subject is certainly a most important one, as the renewal of tramway rails on a large scale will constitute a very heavy burden upon the ratepayers of the metropolis and other large cities and towns.

SMOKE ABATEMENT.—The important conference held under the auspices of the Royal Sanitary Institute and the Coal Smoke Abatement Society certainly took place under climatic conditions that could not fail to bring home to those interested in the subject the necessity for measures intended to diminish one of the greatest among Metropolitan nuisances. The subjects discussed came under three general heads: domestic smoke abatement, factory and trade smoke abatement, and administrative and kindred reforms connected with the question. It is undoubtedly the fact that smoke from domestic dwellings constitutes the chief source of London fog, and although the use of gas fires has increased to a very large extent during recent years, it is extremely doubtful whether householders and others will ever be persuaded to give up the cheerful open fire, which, in addition to its comfort, serves the most useful purpose of assisting ventilation. Sir George Livesey very naturally looks upon the adoption of gaseous fuel as the remedy for domestic smoke, while others who contributed papers, suggested the wholesale employment of producer gas, and of coke as domestic fuels. Of these alternatives ordinary coal gas certainly seems the most suitable at the present time. In view of the fact that the domestic fireplace will not be entirely superseded for many years to come, much interest attaches to the tests recently conducted by the Coal Smoke Abatement Society, with the object of ascertaining the most efficient form of grate, and the same applies to the experiments made in connection with the selection of stoves for the new Government buildings in Whitehall. With regard to factory chimneys in the metropolis, it must be admitted that some improvement has already been effected, and a good deal more could be done for the mitigation of the smoke nuisance if boiler makers and the owners of power plants would pay more attention to the proper design of furnaces. On this part of the question we are inclined to agree with the remark of Sir William Preece that abatement of the nuisance is far less likely to be attained by fines than by convincing the owners of factories that practical savings can be effected by diminishing the amount of combustible discharged into the air in the form of smoke.

MATERIALS OF CONSTRUCTION UNDER PURE SHEAR.—Comparatively few reliable data are available relative to the shearing strength of metals and other structural materials, and as the paper read by Mr. E. J. Izod before the Institution of Mechanical Engineers contains a good deal of useful information on this subject, it ought to be generally appreciated by engineers. The paper describes the character of experiments carried out at University College Engineering Laboratory, and undertaken in the first instance for the purpose of ascertaining the effect of shear on cast-iron. Afterwards the investigation was extended so as to include wrought-iron, mild steel, crucible steel, gun metal, brass and other alloys of copper, and four descriptions of timbers. In all tests of the kind it is somewhat difficult to ensure uniform distribution of stress on the section under examination,

the most pronounced hindrance arising from the difficulty of preventing elongation of the outer fibres of the test specimens. With the object of avoiding this disadvantage as far as possible Mr. Izod devised a special form of shearing apparatus, which comprised two hard steel plates with cutting edges between which there was a third cutting plate, sliding between the other two. This device was found to be fairly satisfac-factory, although a certain amount of stretch took place, for about half an inch on either side of the shearing plane. The results obtained from the experiments are tabulated in convenient form and have also been plotted in diagrams for the purpose of comparison. It appears that no general law can be adduced as to the ratio of shearing to tensile strength, but crystalline metals, capable of little or no elongation, appear to be from 20 to 25 per cent. stronger in shear than in tension, and ductile metals to be weaker under the same conditions to the extent of from 0 to 50 per cent. according to their general character. In the case of timber tested across the grain, the resistance to shear is shown to be from 33 to 53 per cent. of the resistance to tension, and when tested along the grain the shearing strength is not more than from 5·5 to 10·4 per cent. of the tensile strength.

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ROAD DUST PREVENTION.—In his paper read before the Automobile Club, Mr. W. R. Cooper discusses various experiments conducted by the dust committee of the club with the object of inquiring into the possibility of designing motor cars in such a way that the raising of dust might be brought down to a minimum. It is certainly very desirable that this feature of motor car design should receive the closest attention from makers, because, whatever improvements may be effected in the way of dust-less construction for main roads, the smaller highways of country districts will probably remain very much in their present condition and therefore will always be dusty in dry weather. The author points out that considerable difficulty occurs in experimenting with actual cars. For instance, dust raised by the tyres is scattered in various ways by the body, mudguards, dust shields, and other accessories. Consequently the dust raising capacity of a car depends upon several small factors, none of which are necessarily very important in themselves although the sum total may produce very bad effects. It occurred to the author that the difficulty might be eliminated by working on an experimental scale with simpler conditions than those obtaining on an actual car. Therefore he made a model car which he caused to travel along a board at the rate of 20 miles an hour, lycopodium powder being spread so as to represent dust. These experiments were abandoned owing to their unsatisfactory character and the difficulty of obtaining reliable records. A tricycle was subsequently used in the open air, dummy bodies of different shapes being fitted to the machine. Although the results obtained from the experiments made with this apparatus are not conclusive and merely serve to confirm what is already known, it seems probable that if further developed, the method will be of considerable value in future inquiries.

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THE BRIGHTON RAILWAY ELECTRIFICATION.—The recent announcement that the directors of the London, Brighton and South Coast Railway have finally decided to proceed with the conversion of one portion of their suburban railways to electric traction is a gratifying sign of progress, although it is to be regretted that the work is to be placed in the hands of a German firm, the Allgemeine Elektricitäts Gesellschaft. Considering the number of large electrical concerns in this country, many of our readers may wonder why it should have been thought necessary to send the work abroad. The reasons given are that the German firm alone were able to give satisfactory guarantees as to the operation of the apparatus and installation generally; that the details of their scheme were far more complete than those furnished by other firms, and that their price was by far the lowest. Under these circumstances it is not altogether surprising that the railway company should have made the decision which has been announced. Fortunately, however, the purchase of German machinery and apparatus will not involve so large a loss to this country as that represented by the total amount of the contract, for while the electrical equipment for some of the first trains will be made abroad, the bulk of the remaining work—including the construction of vehicles, motors, switch gearing, and other apparatus—will be manufactured in this country. We do not often find railway companies on the south side of the Thames ready to lead the way in improvements, and it is extremely gratifying to find that the directors of the London, Brighton, and South Coast Railway have become the pioneers of single-phase electric traction on a large scale in this country.

# Sub-Aqueous Foundations, with Recent Examples of the Use of Compressed Air.—II.

*By J. E. TUIT, M.Inst.C.E.*

In the last number I briefly referred to the progress that had been made in recent years, in using compressed air for sinking the cylinders and caissons of sub-aqueous foundations, and traced the development of the pneumatic process from the introduction of the diving bell, to the building of the piers at the Forth Bridge.

I now propose describing, in a somewhat more detailed manner, how this system was employed at the reconstruction of the Swale Bridge, near Sheerness, and at the Railway Viaduct over the river Barrow in the South of Ireland, two undertakings presenting more than usual difficulty, but which have just been successfully completed.

*The Swale Bridge.*—There has already been published a short account, with illustrations, of the Swale Bridge (see THE ENGINEERING REVIEW, vol. 12, pp. 519—521), but these remarks referred more particularly to the new superstructure, and the removal of the old opening span, leaving the special operations in connection with the foundations to be dealt with on the present occasion.

The old bridge has been built nearly fifty years and is not only used by the South Eastern and Chatham Railway for their Queenborough and Sheerness service, but also provides a roadway for pedestrian and vehicular traffic. Until a few years ago it was possible to open the double bascule span for the river traffic, but it was considered that the unsatisfactory condition of the piers caused this operation to be rather

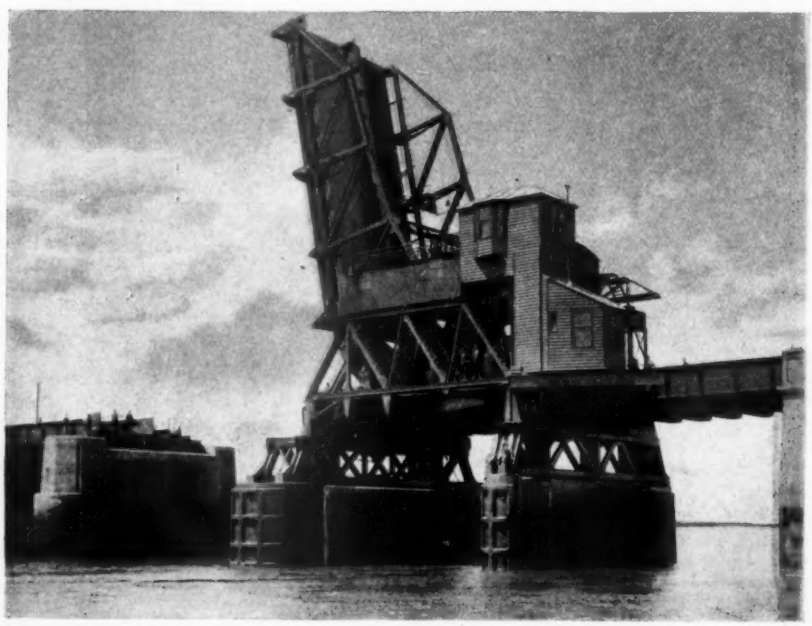


FIG. 1.—THE SWALE BRIDGE: NEW CAISSON FOUNDATIONS AT END OF EXISTING PIERS.

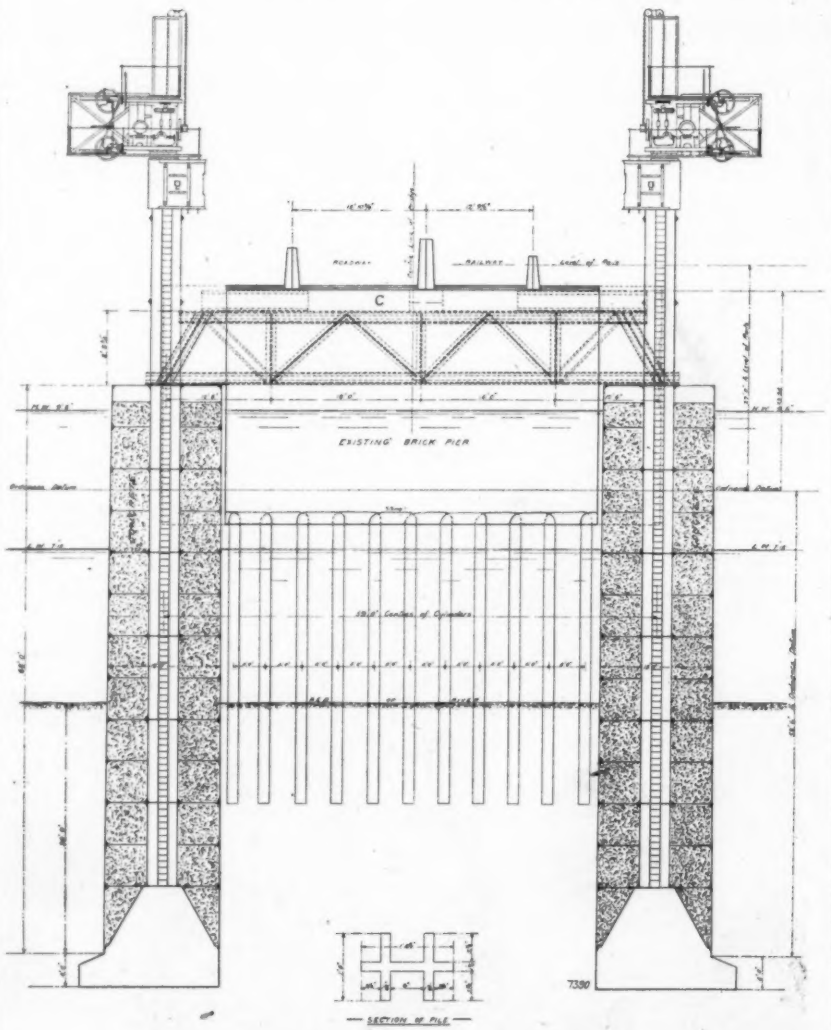



FIG. 2.—SWALE BRIDGE: SECTION OF LARGE PIER

hazardous and, consequently, it was discontinued, and the stability of the whole structure was then much increased by rigidly connecting together the two moving leaves. The bridge was thus rendered perfectly secure and strong enough for its work, but the river authorities very naturally objected to this interference with their interests as nearly all vessels with fixed masts were precluded from passing under the structure. So, after much time had been wasted in one way or another, it was agreed to entirely reconstruct the opening span, and thus again to provide facilities for the shipping using the river.

It then became necessary to decide on the best manner that could be adopted to carry out this work, that the least possible inconvenience should be experienced by those using both the bridge and the river. The railway company would not permit their traffic being interrupted even for an hour, and the conservators were not disposed to permit such temporary staging being placed in the fairway as was really necessary to enable the new bridge to be constructed in the ordinary way. In addition to these obstacles, it was found, after careful examination, that the old brick piers were not sufficiently strong to permit of any extra load being placed upon them, as they were only carried by cast iron piles driven some 25 ft. into muddy clay forming the bed of the river. The insecurity of the piers became very evident at low tides, as it was then possible to see beneath them, they thus presenting the appearance of being carried on "stilts," and making it quite apparent that any interference with their foundations would imperil the stability of the whole structure.

The method of reconstruction ultimately decided upon was as follows:— It was considered desirable to remove a portion of the brickwork at each end of the piers to make room for caissons to be sunk by the pneumatic process in the position shown in Fig. 2. Such caissons being in place and completed would allow the upper portion of the body of the brick piers being gradually removed, care being taken, of course, to support the old superstructure during the operation. Sufficient space would thus be made available to erect the girders C shown in the figure, resting upon the caissons by which the weight of the opening portion of the bridge about to be constructed could be transferred to the new foundations.

The caissons are 15 ft. by 14 ft. in plan and 68 ft. high. They are composed of steel plates and angles, and weighed when completed 66 tons each.

As soon as the brickwork had been removed and the cast iron piles beneath had been drawn, a timber stage was constructed to support the caissons during their erection, and when they had been built to a sufficient height and the riveting was completed they were lowered, by means of hydraulic jacks, so as to rest on the bed of the river. The remaining steelwork was then erected, and the air shaft and lock put into place, and everything prepared for commencing the sinking. No special difficulty was encountered in performing this portion of the work, but it will be seen, on referring to fig. 2, that the greatest care had to be exercised on account of the proximity of the caissons to the old pier, and the necessity of sinking them so far below the existing cast-iron piles, which at that time were entirely supporting the bridge. The full air pressure was consequently always maintained, and caused to vary in accordance with the state of the tide.

The sinking was commenced in the usual manner by sending a man down to the working chamber to clear away the material which had accumulated at the bottom of the air shaft. The size of the chamber only permitted two men to work effectively at a time, but as the maximum air pressure was only 30 lbs. per sq. in. above the normal, there was no difficulty in working three hour shifts. Two men were also needed to attend to the air-lock and empty the skips as they were sent up from below. The work was carried on night and day, and the material excavated per three

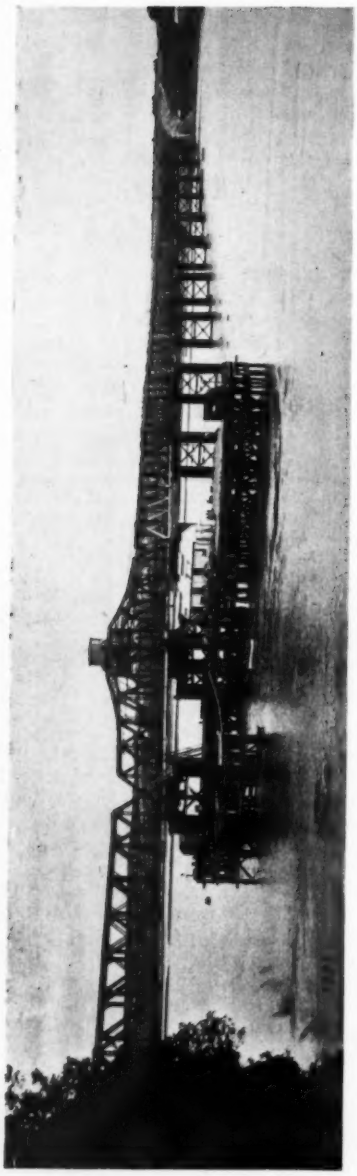


FIG. 3.—THE BARROW VIADUCT.

hour shift averaged 12 cubic yards, the rate of sinking being about 2½ ft. in 24 hours when all was going well, but allowing for the time lost, through one cause or another, three weeks were taken to sink each caisson the full depth of 40 ft.

There were no serious cases of illness amongst the men working in the compressed air, owing, no doubt, to the moderate pressure and the care exercised by those in charge of the operations to take such precautions as past experience had shown to be necessary in carrying out work of this character. The caissons having been sunk to the required depths, it was decided to increase the area of the foundations by "undercutting" them. This was done in small sections at a time, the trenches thus made being 4 ft. wide and 4 ft. deep, and projecting beyond the caissons about 3 ft. As each of these holes were made the cutting edges were supported by timber blocks, until all were completed. The blocking was afterwards removed, section by section, and the holes filled with concrete, and the permanent work thoroughly grouted up to ensure a good bearing being obtained. The working chambers were then filled with concrete and the foundations thus completed. The whole of the work was successfully carried out, without any mishap, but it was not until the girders C. (Fig. 2) were placed in position, and made to transfer the weight of the superstructure to the new foundations, thus relieving the old piers, that all cause for anxiety was removed.

*The viaduct over the River Barrow, Ireland.*—The new direct route between London (Paddington) and the South of Ireland, which was authorised by Parliament some five years ago, and is now being made by the Great Western and Great Southern and Western Railway Companies, is nearing completion, and it is hoped will be ready for traffic by next summer. The scheme necessitates improved harbours near Fishguard, in South Wales, and Rosslare, in county Wexford, Ireland, in addition to a new railway about thirty-five miles long between the latter place and Waterford,

and its extension to the point where it joins the present main line to Cork. Although the new railway is comparatively short, its construction involves much important work, it being necessary to build viaducts over the rivers Barrow and Suir, the former having a length of 2,131 ft. and the latter 1,205 ft.

The Barrow viaduct has now just

FIG. 4.—BARROW VIADUCT: SINKING THE CYLINDERS.

been completed. It is the longest bridge yet constructed in Ireland, and has been designed for a single line of railway (5 ft. 3 in. gauge). It consists of thirteen spans of 140 ft. each, and two opening spans of 80 ft. each, operated by electricity generated at the site.

The work, however, would not merit any special mention were it not for the great depth it was found necessary to sink the cylinders, many of which, owing to the unsatisfactory nature of the ground, had to be sunk from 100 ft. to 117 ft. below high water, a distance which has not been previously attained by the use of the pneumatic process. The cylinders are from 11 ft. to 12 ft. diameter, and composed of cast iron, with the exception of the lower portion, which is built up of steel angles and plates. They were sunk very much in the same manner as those at the Swale Bridge above referred to. It was expected that a sufficiently good foundation would be met with, at a depth of 60 ft. to 70 ft., but this did not prove to be the case, and it was not until these figures had been exceeded in some instances by 50 per cent. that the

ground was considered suitable to carry the load to be placed upon it. The maximum air pressure to which the men were subjected was 44 lbs. per square inch above the normal, but this was, in most cases, kept down to 40 lbs. by using "ejectors." The sinking operations were carried on night and day, the average distance sunk in twenty-four hours being three feet. The air pressure was always maintained, and made to vary with the tide.

Only two men were able to work at a time in each cylinder, but even under the extreme pressure these could work a three hours' shift, including the time taken in entering and leaving the air lock. Notwithstanding the high pressure, there were no cases of serious illness, and this was, no doubt, largely due to the men being in good health, and to the fact that they were compelled to take from twenty to thirty minutes to pass through the lock, and on leaving work, being supplied with hot coffee, in a cabin, where they were forced to remain for at least half an hour.

In conclusion, it may be mentioned that the contracts for both the Swale Bridge and the Barrow Viaduct, were carried out by Sir William Arrol & Co., Ltd., of Glasgow, the writer being associated with them in the execution of these works.

## The Design of Engineering Workshops—II.

*By H. MUNCASTER.*

THE first demand in the foundry is for efficient lifting appliances. So much lifting is required that the weight of the casting turned out is only a small amount in proportion to the total amount of weight of material to be handled. The full available power must also greatly exceed the weight of the heaviest casting it is intended to make. For instance, a casting weighing, say, ten tons only may require a total lift of twenty to thirty tons to drag it from the sand, or a loam mould, which may be several times the weight of the finished casting it is to contain, has to be lifted into a drying stove or into a pit for casting. While for this reason it is necessary to provide ample power, it is at the same time needful to supply suitable cranes of a size and power for the expeditious handling of smaller loads, otherwise, it must result in much unnecessary wear and tear, as well as an expenditure of power out of all proportion to the work done. It is, therefore, very desirable to employ in addition, cranes suitable for loads up to say one to two tons only.

In arranging the capacities for the travelling cranes, it is well to take into consideration that more than one crane may be employed at the same time in dealing with an extremely heavy load. This fact may modify to some extent the need for a very powerful crane, also the strength of the structural work in the gantries, as the weight will be more evenly distributed, although the total weight of the several cranes may considerably exceed the weight of one crane. In designing the columns and the gantry girders, the possibility of several cranes being on the same girder at the same time must not be overlooked.

In the matter of lifting appliances, there is another feature about the requirements of a foundry differing from those of other departments. It is that circumstances frequently make it necessary to retain a load suspended from the crane for a considerable time, as in cases where the top of a mould has to be lifted up, dressed, cores fitted, and work done of various sorts, involving time and labour, before it can be replaced, or where cores have to be fitted to some part of the interior before the upper part of the mould can again be replaced. If the travelling cranes were utilised for this purpose, other work in the foundry would be seriously hampered by the blocking of the gantry, therefore a series of jib cranes of suitable range and power are

fitted to the walls of the buildings or to the columns supporting the gantries. Each of these cranes may be available for the convenience of a group of moulders working within the radius of the sling.

This class of crane is very conveniently worked by hydraulic pressure. The power required may vary considerably, a small proportion only may equal four or five tons capacity, the remainder suitable for a maximum load of say two tons and under.

Where electric power is supplied to the building these cranes may be worked by a motor, which is used for lifting only, the racking being done by hand, and where roller bearings are fitted at the top and bottom of the pillars, there is no difficulty in swinging by hand the crane to any position. An outline of such a crane is shown on the section of the foundry (Fig. 5). The strut should be in the form shown so as to interfere with as little as possible the lifting or turning of the moulding boxes, &c. It is not desirable to use power except for lifting.

It is very necessary that the pillar be exactly vertical, otherwise the crane will swing round until the weight finds its lowest position. A simple jib with a trolley from which is slung a pair of chain blocks worked by manual power is very handy for use where the lighter classes of moulding are done, and is much appreciated by workmen engaged on work where the boxes require careful lifting or where cores have to be set with great accuracy. The power cranes are quite satisfactory in this respect. There is, however, in the hydraulic crane some danger of "creeping," if the load be left suspended, owing to leaky valves or glands, and some damage may result thereby.

A corner of the foundry may be used for dressing the castings before being sent out to the machine shop. For this purpose also, suitable crane power should be available, enabling a casting to be slung up and dressed, as it hangs, when desired.

A band sawing machine, a few drilling machines and one or two emery wheels will be found serviceable.

A very convenient and useful arrangement for moving loads of moderate weight is provided by hanging from the roof girders or other convenient support

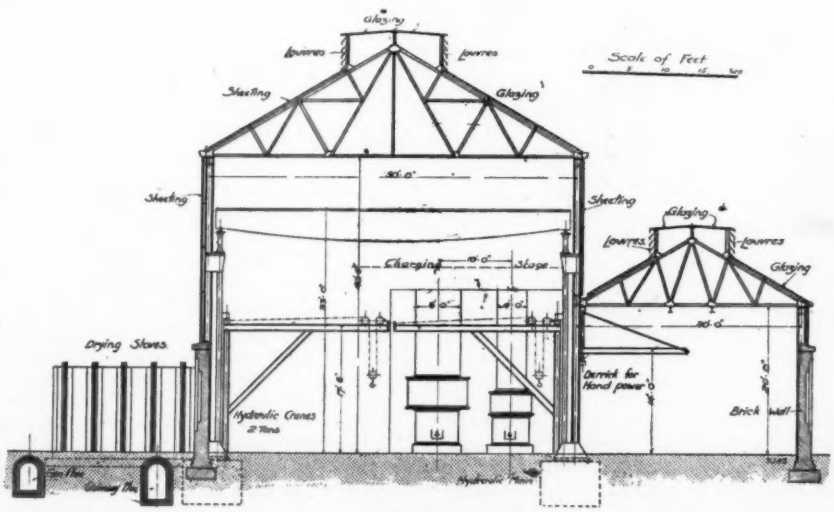



FIG. 5.

an H section beam, on the bottom flange of which run the wheels of a trolley carrying a sling or chain blocks, from which a load can be lifted and suspended or run down the shop. These rails and trolleys are of great utility for a variety of purposes, and are so simple and inexpensive that the wonder is they are not more generally employed. In a foundry this system has all the advantages of a tramway without taking up any space on the moulding floor, and if the suspended load be kept up a few feet above the floor it can generally be passed over any work that may be in hand without inconvenience to the moulder.

It will be very necessary where there are jib cranes swinging from several columns to have the building efficiently stayed by cross-bracing. The ties of the roof principals should for the same reason be of angles or tees, so that they may serve to act as struts where the strains are in compression.

*Cupolas.*—The size of the melting cupolas will, of course, depend on the amount of metal required. It is often a wise policy, if not a necessity, to have two cupolas available, and as the output may vary considerably from day to day, it will be advantageous to have the cupolas of different sizes.

*Drying Stoves.*—There is a considerable amount of drying to be done in the cores and loam moulds in ordinary foundry practice. Where ample lifting power is available, and stove accommodation is provided on a liberal scale, most of the work of drying should be done in the stoves.

The custom of lighting wood and coke fires in the middle of the foundry for drying purposes should only be allowed where necessity demands, as it is attended by so much mess and discomfort to everyone at work in the foundry, and only can be done at a great sacrifice of economy and efficiency. There are, of course, many cases where on account of the extreme size of a casting it would be difficult to mould it in a box, and there is no alternative, but where the mould can be made in a suitable box it is preferable to use it and so enable the work to be dried in a stove where it can be done more thoroughly than on the floor.

The moulding boxes, when ready for drying, can be lifted on a trolley and pushed into the stove.

Fig. 6 gives the details of a stove fired by producer gas.

The stove is built of common brick, with a $4\frac{1}{2}$ in. lining of firebrick or of fairly good refractory material. A 9 in. arch of firebrick is turned over the crown to a radius equal to the width of the stove. To take the thrust of the arches at the spring, buckstaves of double headed 65 lbs. rails or similar I bars are arranged in pairs along the outside, behind a plate which is about $\frac{3}{8}$ in. thick and 2 ft. wide. The feet of these bars are set into the concrete foundations of the walls. The buckstaves at the opposite ends of the stoves are tied together by $1\frac{1}{4}$ in. diameter bars, having $1\frac{1}{2}$ in. diameter screwed ends, stretched across the top of the stoves.

The stoves are usually arranged in pairs with the tie bars extending right across. It is better, however, to arrange the bars so that each stove shall be complete in itself in case it should be necessary to keep one stove intact during extensive repairs or alterations to the other. The heating is done by producer gas led behind the range of stoves in a 3 ft. 6 in. by 2 ft. 6 in. brick culvert. The gas is admitted through an iron valve into a chamber at the back of the stove. The air necessary for combustion is admitted through openings near the gas valve. These openings of about 9 in. by 3 in. may be two in number to each 10 in. gas valve. A sliding shutter may be fitted over the opening to adjust the amount of air admitted. In practice, however, a common brick placed partly across will answer quite well, and is not likely to stick. A fresh adjustment of air admission is required each time the gas valve is altered, only sufficient air being admitted to ensure perfect combustion.

Lifting doors of steel plate, say $\frac{1}{4}$ in. thick, stiffened by tees and angle framing, are fitted over the opening into the

stoves from the foundry. These doors should be of a size sufficient to cover as large an opening as it is possible to have into the stove. In the case of the stoves illustrated the width of the opening is 10 ft. 6 in. and the door 11 ft. total width.

Cast iron stanchions are fitted (shown in section) at each side of the opening to act as guides for the doors; each stanchion extends upwards a little over twice the height of the door and

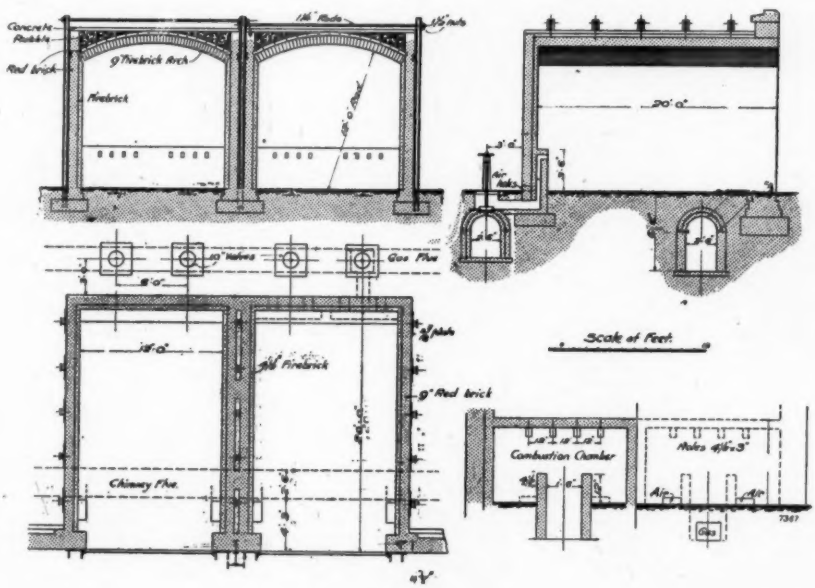



FIG. 6.

carries a pulley over which runs a wire rope or chain attached to the top of the door at one end and a balance weight at the other end. The doors lean against the stanchions but are free to swing away from the stoves so that in case of any explosion of gas inside the stove they act as a relief valve to prevent the destruction of the brickwork.

If producer gas be not available, a small coke or coal furnace must be built against the side or against the end of the stove in the place of the gas furnace shown. For a 12 ft. stove, as shown, a grate of about 12 ft. area will suffice. The opening to the chimney flues will be the same in each case whether the stoves be gas fired or coal fired.

The best way of using the stoves is to have a trolley with an iron plate on which the drying is done. The trolley is loaded up, pushed into the stove and the work dried. This arrangement is most convenient, as it enables the heaviest work to be handled by the large cranes in the foundry. The axles of the trolley should be made to roll under the platform, and not be fixed in the usual bearing, as it is impossible to lubricate them on account of the great heat inside the stove.

Two points are often neglected which do not involve a question of cost at all, but simply of design. The first is that the lighting of a foundry, which seems a simple matter, is often defective; a few square feet of glazing is judged sufficient

to light a large building, and as a consequence the work is carried on in comparative darkness or artificial light is required, which is expensive and unsatisfactory in comparison with daylight. Glass is very cheap,—cheaper than slating, and if not so cheap in first cost as sheet iron, is certainly not so liable to corrosion, and in spite of breakage is less expensive to keep in order than sheeting. A good sample of glass may be supplied at about twopence per foot square, and the cost of putty and astragals (which should be of steel or iron) is sufficiently low to make it compare favourably with any form of roof covering. In the design illustrated more than half the area of the roof covering is of glass.

The second point is that the ventilation is often defective, and some parts of the building are swept by a strong current of air, while in other parts the air is quite stagnant, and the fumes from the casting or drying fires hang like a pall.

There should be no great difficulty n ensuring a fairly uniform ventilation in every part. In cases similar to the example given there is a considerable difference of level in the various spans of the roofing. There is often a steady current of air drawn in at the louvre ventilator on the lower roof, and passing out at the ventilator on the higher roof. There is also a strong current passing inward at any door that may be open. To ensure efficient ventilation it is necessary to admit the air at a low level, say 7 feet above the floor, and to distribute the inlets as much as possible. A liberal amount of openings, say equal to 5 feet square to each panel of the walls, with blades to deflect the air upwards will answer admirably. If windows are fitted in the panels of the walls, a row of panes may be arranged to swivel and form an inlet for fresh air.

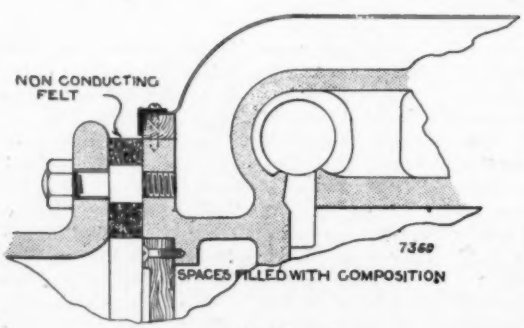



FIG. I.

## Suggestions for the Construction of an Economical Steam Engine.

*By C. H. B.*

THE following suggestions for an economical steam engine have occurred to the writer after some consideration of the problems which present themselves when seeking to improve the steam engine. The writer is quite willing to admit that some of the points suggested do not possess much novelty, but the combination of features here advocated has not, so far as the writer is aware, been incorporated in the design of any engine.

Of many of those engineers who have spent much thought on the problems of the reciprocating engines, it would not be too much to say that they regard the rapid advances of the gas engine and the steam turbine with something like regret; for a long acquaintance with the reciprocating steam engine and its many fascinating problems, engenders a regard which no other type of engine or machine can supplant. Many old engineers had a similar feeling for the beam engine when that beautiful type became displaced by more modern designs. Any suggestions, therefore, which promise advancement in the reciprocating steam engine will be of interest to many, although they may dissent from the opinions and designs here brought forward.

The first matter claiming attention is the insulation of the cylinder; and the writer believes

that if this question were properly studied, the result would be a perceptible advance in the economy of steam engines. There can be no doubt that a considerable loss is sustained by the conduction of heat that takes place through the frame-work of the engine. As engines are usually constructed the planed face of the cylinder is bolted against the bedplate or standard, and there is no check to the conduction of heat from the hot cylinder to the cool frame. In horizontal engines a large foot is usually cast with the cylinder and bolted either to the bedplate, or directly upon the foundations. In either case the foot is exposed to the cooling effect of the atmosphere. The method suggested for overcoming the difficulty is shown by Figs. 1 and 2. The first figure shows the connection between the trunk and the frame. The bolts forming the connection are provided with collars, against which the faces are bolted, and the space is filled up with a sheet of felt or other non-conducting substance. In Fig. 2, similar arrangements are provided between the feet and bed-plate of a horizontal engine. The ribs forming the feet should, however, be completely enclosed. In "Corliss" engines the same construction might be applied to the dashpot fixing, and to any other brackets which conduct the heat from the cylinders.

In the lagging of the cylinders the sheet steel must in no place touch the metal of the cylinder, and no portion of the flanges of the cylinders must be exposed if the insulation is to be efficient. A frame of well-seasoned timber resting on the cylinders and forming the support for the lagging is suggested, and the space thus formed being filled up with composition. The nuts in the cylinder could be placed in pockets, and made accessible by box spanners. By this construction no portion of the cylinder is exposed, nor any edges or faces of flanges. All protruding feet would be lagged, and all loose fittings insulated as above described.

In choosing the type of valve-gear for the engine the writer has placed the reduction of clearance spaces, perfect cylinder drainage and the machinery of all parts in contact with expanding steam as the chief features to be obtained. No attempt has been made to obtain a beautiful diagram. Of all types of valves there is none which gives so small a clearance as the "Corliss" valve when placed in the covers. To be successful, they must be arranged to drain the cylinder effectively. Trip gear is satisfactory in respect to governing and steam distribution, but it suffers from the defect that 130 revolutions is about its maximum satisfactory speed. There is no

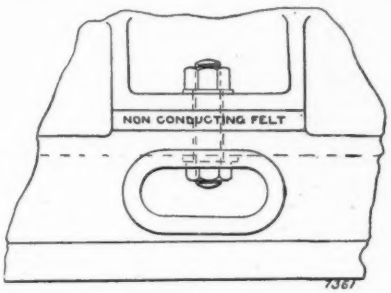



FIG. 2.

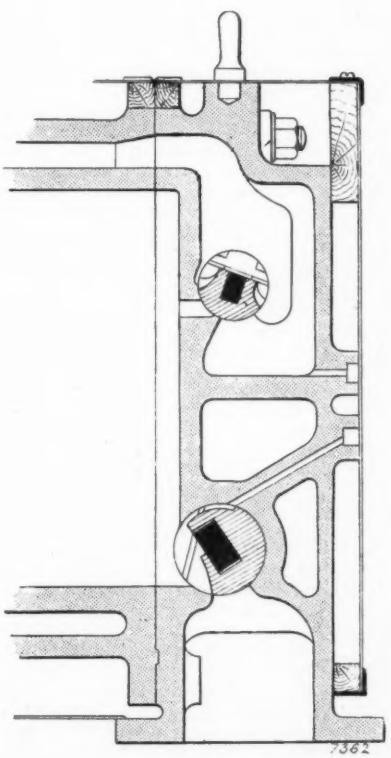



FIG. 3.

economy resulting from high speed *per se*, but it is convenient to adopt it when

possible in order to keep down the size of the engine. The writer therefore suggests a crank shaft governor to regulate the valves. This type has been much discredited in some quarters, but there are successful types now at work giving the greatest satisfaction, the "Robinson" governor and "Maclaren" being interesting examples. The suggested arrangement of valves and cylinder end, is shown by Fig. 3. The steam valves are under governor control, the result being regulation by combined throttling and automatic cut off. The exhaust valves are driven from a separate eccentric and have a constant swing. This is an important point with an engine having such a small clearance, for if the exhaust were delayed, as would be the case if the steam eccentrics were employed to drive them, there would be a dangerous rise due to compression. The feature of the steam-valves is the small area of port, giving, when the valve is wide open, a steam velocity of 220 ft. per second. The object of this is to reduce clearance, throw of eccentric and area of surface exposed to expanding steam. The effect on the diagram would be a sloping admission line, but few will maintain that this means a reduction of efficiency, whilst the advantages obtained are considerable. The whole surface of the steam port is tooled. The exhaust valves give a very liberal opening, and the mean velocity of steam through the port does not exceed 95 ft. per second. The situation of the exhaust valve is similar to that in the "Farcot" engines, the object being to cut down the clearance and obtain machined faces exposed to expanding steam. The faces of the piston are machined as well as the covers, and the clearance between piston and cylinder is $\frac{1}{8}$ inch. With such small clearances it is essential that the design of the connecting rod must be carefully considered and the wear at each end must have a neutralising effect, and the effect of expansion in the piston-rod must be allowed for.

By adopting these features the clearance is reduced to 1 per cent. with a cylinder 20 ins. diameter, 30 ins. stroke, which is considerably less than in any other type of engine. Moreover, the cylinder is very effectually steam jacketted, both on the barrel and the heads of the cylinder, whilst the drainage is perfect. The other features of the engine would follow on the lines adopted in high-class engines, special regard, however, being given to the valve motion to avoid overhanging pins and rocking of the valve levers upon the spindles.

The writer believes that an engine designed on these lines would surpass in economy any existing reciprocating engine of similar power, and working under the same conditions, and that up to 1,000 h.-p. it would leave far behind any steam turbine yet made.

# Results of Recent Experience in the Bacterial Treatment of Sewage.

*BY W. H. MAXWELL, A.M.Inst.C.E.*

During the past decade the great bulk of scientific thought, as applied to the disposal of sewage, together, as a natural sequence, with the generally recognised practice of the engineering operations involved, has been diverted almost wholly to the development of bacterial systems of purification. It is not intended, within the scope of the present article, to trace through the history of the beginnings and subsequent development of that interesting field of bacteriological knowledge which has led up to the present position of the problem of sewage disposal, but rather to notice recent developments in connection with the practical application of bacteriological processes to the every day treatment of a town's sewage. Although the necessary presence of minute life for bringing about putrefactive and fermentation changes had been long recognised, and the cultivation of low organisms on a large scale for purposes of purification had been seriously proposed, it was not until the Massachusetts State Board of Health, in 1887, commenced their well-known experiments on the purification of sewage and water, and subsequently issued their valuable Reports, that the foundations of modern bacterial processes can be said to have been laid.

Following shortly upon the issue of these records, now of classical interest, bacterial trial filters were put down at Barking by the London County Council in 1891, and in the same year Scott-Moncrieff obtained good results in the liquefaction of sewage on anaërobic lines in his "bacterial tank" at Ashtead. The next practical steps of importance were the installation of "contact beds" at Sutton (Surrey) in 1895-6 by Mr.

Dibdin, and the introduction of the "septic tank" at Exeter by Mr. Cameron, the city surveyor, in the same year.

From these beginnings, the bacterial system of sewage disposal has developed apace during the last few years in almost every civilised part of the world.

In several of the largest towns, where a heavy capital outlay would necessarily be involved in altering the system of treatment, it was promptly and wisely decided to put down experimental works in order to carry on a series of practical experiments for the purpose of investigating the suitability of bacterial methods for the purification of the particular sewage to be treated. It was at first thought that whilst sewages mainly of a domestic character could be thus purified, the successful application of the system to the sewage of a manufacturing centre was a doubtful proceeding. To set this point at rest was one of the leading objects of the experiments carried out for the City of Manchester during the year 1898-9 by the Manchester experts, who reported (in October, 1899)

> "That the bacterial system is the system best adapted for the purification of the sewage of Manchester, and that any doubts which may have arisen in the first instance as to its suitability, owing to the presence in Manchester sewage of much manufacturing refuse, have, through the convincing results of our experimental enquiry, been entirely banished. . . . The results obtained have altogether exceeded our expectations as to the possibility of purifying a manufacturing sewage, inasmuch as it was previously a matter of common belief that in such a liquid only a most insignificant amount of nitrification could be induced."

Amongst other towns, which have carried out a like series of experiments for the purpose of independently establishing the fitness of the bacterial system to the solution of the local problem of sewage disposal, must be named those of Leeds, Sheffield, Leicester, Huddersfield, and Birmingham, all of which districts are now introducing the system on a considerable scale.

*Chemical precipitation at Glasgow.*—Thus, as a natural corollary to the forward flow of the bacterial wave, the tide has set strongly against certain other processes of purification, foremost among which is that of chemical precipitation; but, in this connection it is of interest also to note that whilst other towns may be said to be rivalling each other in a race to abandon chemical precipitation, with its notorious expense in chemicals and sludge disposal, the city of Glasgow is installing large works of this class at Dalmarnock, Dalmuir, and Shieldhall for the purpose of dealing with an ultimate combined dry weather flow of about 117 million gallons a day. Although the Dalmarnock works were designed prior to the general abandonment of chemical processes, the city did not proceed with that mode of treatment in the two larger works at Dalmuir and Shieldhall without making careful inquiry and independent test of septic tanks and double contact beds at Dalmarnock in the year 1900-01. The degree of purification attained by double contact was 95 per cent., but the loss in the liquid capacity of the beds, which were composed of engine ashes,* was considered high. From this experience it was also computed that an area of no less than 239 acres would be required for septic tanks and contact beds to perform the work accomplished by chemical precipitation on an acreage of 28½ at the two works at Dalmarnock and Dalmuir. The bacterial method would, however, yield a much higher degree of purification than that attainable by chemical precipitation, but practical considerations necessarily impose a limit on achievement in this direction. At Dalmarnock the working result of the chemical process is that all suspended matter is removed and 30 per cent. of purification is attained, calculated on the basis of oxygen absorbed in four hours at 27° C. This result, of course, under other circumstances, leaves much to be desired, but it should be borne in mind that the effluent is discharged into a tidal stream of vastly superior volume, thus lessening the necessity for so high a degree of purification and also that most of the sludge is to be disposed of, in its liquid state, at sea. It was also found that in the case of the large works contemplated at Dalmuir the capital expenditure on a bacterial system would have been many times greater than the estimated outlay for ordinary precipitation works. For these reasons it was decided by the Glasgow authorities that they were not justified under the circumstances in departing from the system already in use at Dalmarnock.

*Analogy between bacterial processes and treatment on land.*—The underlying principles involved in the treatment of sewage by what is now understood as the "bacterial process" are substantially the same as those which bring about its purification on land, and the recent developments of bacterial

* *First contact*, bottom layer 9 in. depth of ¾ in. ashes, middle layer 1 ft. 9 in of ½ in. ashes, and top layer 9 in. of ¼ in. ashes; total depth 3 ft. 3 in. *Second contact*, bottom layer ½ in. ashes 8 in. in depth, middle layer ¼ in. ashes 7 in. in depth, and top layer ⅛ in. ashes 2 ft. depth, making 3 ft. 5 in. in all.

methods have directed further attention to many important points in regard to land treatment. The sewage farm effluent is strictly comparable with that derived from bacteria beds, the latter process being in no way "new," but identical with that which obtains in nature—hence, it is in this direction that the solution of the sewage problem should be sought.

*Land treatment.*—A good deal has been heard from time to time of the failure of sewage farms to perform the functions expected of them, and there has, of late, been a tendency in some quarters to turn somewhat hastily to other modes of treatment. The practical application of recent advances in bacteriological knowledge has, however, given a new and increasing interest in the scientific purification of sewage on the greatest of all bacteria beds—the land. That there have been many failures cannot be disputed, but when the causes of such are suitably investigated in the light of present knowledge, it will be at once apparent that no other result could fairly be anticipated. In the great majority of cases, failure to efficiently purify has been due to some one or more of the following causes:—The biological principles involved are not infrequently entirely disregarded, and due attention is not paid to the capacity of the land in respect of the quantity of sewage that can be satisfactorily dealt with thereon. Another fault commonly met with is that of localising the sewage upon certain parts only of the total sewageable area, whilst the remaining areas are reserved for cropping and profit-earning purposes; in other words, the various areas are not sufficiently alternated in periods of work and rest. Former sewage "filters" failed by choking owing to want of appreciation of the necessity for alternating periods of *rest*, and all land requires like opportunities for the proper digestion of the impurities brought upon it. Suitable cropping is an aid to purification and especially to the recovery or cleansing of land which has become "sewage sick" through being over-worked with sewage.

The monetary aspect of sewage farming has an important bearing upon the success or otherwise of the treatment afforded. Farms in general cannot be expected to yield a profit if interest on capital expenditure is taken into account, although during favourable seasons with good cropping, the working expenses may be more than covered. But herein lies the danger which makes for failure if not carefully guarded against. The farm, it must be remembered, is for the purpose of the disposal of the sewage of the town, and the growing of crops is to be regarded as a means of cleansing and recovering the purifying power of the land in order that it may be again brought into a suitable form for the receipt of more sewage upon it.

Provided it is properly handled, land will continue to satisfactorily purify sewage for a practically indefinite period, and there are many farms in use to-day which have been satisfactorily operated for purposes of sewage purification for the past thirty years. But successful working involves continuous intelligent management, and a sufficient area of suitable land. The sewageable area of land must be increased in proportion to the increase in population served by the farm, in the same way that any other works require to be extended and adjusted from time to time to the increasing amount of work demanded of them.

But it is just at this point that it becomes practically impossible to deal with the sewage of large populated centres by means of land treatment. The area of land required to satisfactorily deal with a given volume of sewage is a question requiring careful consideration in each individual case. Full regard must be paid to the physical and other characteristics of the land, to the strength of the sewage to be treated, and to the preliminary screening and precipitation of the liquid before application to land. The depth of top soil is also an important factor as nearly all the purification is done, even in the case of porous soils, in the upper three feet of the land. The amount of rainfall upon the land also has an important bearing upon its capacity for receiving and dealing with sewage—the greatest saturation occurring just at the time when the volume of sewage to be treated is greatest.

The principal classes of land met with are gravel, light loam, heavy loam, chalk, peat and clay. On what may be termed stiff, harsh lands, experience shows that not more than a maximum of 3,000 galls. per acre per day should be flowed (usually very much less), whilst on the very best land obtainable a volume of 30,000 galls. per acre must be regarded as a maximum quantity. Up to these extremes all sorts of graduations of flow are met with according to the nature of the soil and other conditions.

Under the present Local Government Board rules, if sewage is treated by broad-irrigation on *suitable* land, after rough screening, the requirements are one acre of land for every 150 of the population at 30 galls. per head, that is one acre for a volume of 4,500 gallons. The lands required for final

treatment of the effluent from bacterial beds is one acre per 30,000 galls.

Calculating upon the Local Government Board figure of 4,500 galls. per acre, Manchester would require an area of nearly 10 square miles of land constantly under sewage to deal with a dry weather flow of about 26 million gallons per day, and on the same basis, London would need over 80 square miles of land to deal with a flow of 235 million gallons per day as now treated at Barking and Crossness by chemical precipitation. It is therefore clear that the areas of land required for the effectual treatment of the sewage of large towns frequently become so large as to prohibit the continuance of this mode of disposal and other means of dealing with larger volumes per unit of area must be sought. But for smaller districts where sufficient areas of suitable land can be obtained at a reasonable cost, land-treatment, under proper management, is a natural and efficient means of disposal.

It must not be assumed that the land which is capable of dealing with the largest quantities of sewage effect the greatest amount of purification. The reverse is frequently the case. As in the case of a bacteria bed the features tending towards quality of effluent are largely opposed to those enabling a large volume to be dealt with on a given area. The analogy between the proper working of a bacterial system and the performance of the same work upon land will be found complete when followed through its various stages. Any attempt to force unduly large volumes of sewage through bacteria beds without affording the necessary periods of rest for the proper development of the purifying bacteria and the full digestion of the organic matter carried on to the beds in the sewage produces choking and failure to deliver a purified effluent in the same way that like causes inhibit success on land.

*Principles Underlying the Bacterial Purification of Sewage.*—In the bacterial purification of sewage the work is carried out by natural agencies in what may be broadly regarded as two distinct operations. The first stage consists of the elimination of the grosser suspended solid matters from the sewage as brought about by screening, by subsidence in detritus tanks, and by the reduction of the remaining solids by anaërobic bacterial action in the septic tank. The second operation consists of the conversion of the dissolved impurities contained in the sewage or septic effluent into stable and inoffensive forms. The remaining part of the work of purification is brought about by aërobic bacterial action either upon "contact" beds or "percolating" filters.

In general terms it may be said that the bacterial purification of sewage is brought about somewhat in the following manner: The micro-organisms already existing in the sewage are carried by it into the septic tank, and afterwards on to the bacteria beds. These latter provide an enormously extended surface for the development of bacterial growths, and in this way furnish an ideal habitat for the aërobic bacteria to perform their natural functions, whilst the septic tank with its limited supply of light and air enables the anaërobic micro-organisms to carry on their work to the best advantage, and so to prepare the sewage for subsequent treatment on the bacteria beds. It is found that some time must elapse before the necessary bacterial life in the septic tanks and bacteria beds attains its maximum, and, as a consequence, the purity of the effluent increases with age.

It is seen that the underlying principle of the bacterial purification of sewage involves two distinct stages in the process of disintegration. First, there are the anaërobic changes akin to putrefactive processes occurring in the septic tank, and subsequently follows the aërobic changes, corresponding to what is known as nitrification, taking place in the contact beds or percolating filters. Although the two classes of organisms may carry on their work to a certain extent side by side, it appears that the rate at which each process proceeds is more rapid when the two stages are kept as distinct as possible, which doubtless is one of the contributing causes of the more rapid action of bacterial filters over land. In broad irrigation the distinction between these stages is less marked, but the same two actions occur—the aërobic at the surface of the soil, and the anaërobic lower down.

It is generally recognised that the anaërobic change should take precedence in the process, and that it is an important feature in the preparation of the sewage, but recent experience shows that it should be stopped when a certain stage has been arrived at. When the septic conditions are carried too far the effluent from the tank is liable to cause serious nuisance, especially when sprayed on the "sprinkling" system upon percolating beds, or flowed, as in some cases, over land.

The anaërobic process is found to be more active than the aërobic in the reduction of organic matter in suspension, whilst the reverse appears to be the case in regard to that in solution. In this latter stage the aërobic bacteria, coupled with a thorough

aëration of the tank effluent, remove more organic matter from the liquid in a given time than would be the case under the anaërobic process, and it is therefore important that there should be as little as possible artificial interference with the order of nature.

The preliminary anaërobic treatment of sewage would appear to be well justified on scientific grounds. It is well known that a large proportion of the solid matter to be dealt with consists of cellulose as contained in paper, wood, straw, vegetable refuse, and the like, and, although it is not absolutely clear that cellulose cannot be liquefied aërobically, there are very good grounds for believing that the great bulk of this work is done under anaërobic conditions.

In this connection Dr. H. Marshall Ward has given a very interesting exposition of the work of the cellulose destroying organisms in "evidence" before the Royal Commission on Sewage Disposal.* He states that:

> "The cellulose-destroying organisms have been isolated of late, and found to be anaërobes. They carry on their work of destroying vegetable fibre and vegetable cell-walls, dead leaves, and so forth in the mud, in pools, and in marshes, in ponds, &c., and it is owing to their action that quantities of marsh-gas are given off at various times. And in late researches in Neva mud a cellulose-destroying organism has been isolated, which, provided it is cultivated in the absence of air, fixes itself upon pieces of paper, causes the fibres slowly to swell and dissolve, and, in fact, destroys this fibre, destroys cellulose, and there can be no doubt that substances like paper are destroyed in that manner in the soil or in domestic sewage. This occurs only in the depths, but there have been cases described where actions of this sort can go on nearer the supply of air—say, at the surface of a liquid—provided some other organisms can protect the anaërobic one from the action of oxygen."

Notwithstanding what has been said as to the necessity for anaërobic conditions, it is well known that a large amount of liquefaction of solids can be brought about in a "course bed" under what are generally regarded to be aërobic conditions, but it appears very probable that the changes taking place in the depth of the filter are anaërobic.

*Necessity for the preliminary preparation of Sewage prior to Land or Bacteria Bed Purification.* — The preliminary removal or reduction of the grosser solids is essential, whether the final purification is effected on land or in bacteria beds. Land rapidly becomes choked and sewage sick by the application of the crude liquid except when in very small quantities, and in the same way the bacterial filter may be overdosed with organic impurities, and in that case must receive prolonged periods of rest to prevent choking. In the course of experiments carried out at the Beaumont Leys sewage farm at Leicester, it was found that after the sewage had received a preliminary treatment by being passed through detritus tanks and first contact beds, quite three times the quantity could be dealt with on the land as compared with the volume that could be put upon it without this treatment.

The need for preliminary treatment before passing sewage on to bacteria beds was experienced in the Leeds experiments, where it was found that the crude sewage clogged the surface and prevented aëration of the filter. Considerable trouble from this cause has been experienced at Hampton-on-Thames, and a hydrolytic tank has recently been put down in order to subject the sewage to the necessary preliminary preparation.

*Stages in the Bacterial Treatment of Sewage.* —In the first place must be provided suitable provision for the *screening* of the sewage and removal of the larger floating material such as paper, sticks, and other rubbish. Next follows *detritus tanks* in which the heavy mineral matters such as sand, road grit, &c., carried in the sewage may deposit, before the sewage enters the *septic tank* where the breaking down of the organic matter in suspension takes place, and so prepares the liquid for the final stages of purification upon first and second "*contact*" *beds*, upon *percolating filters*, or upon the surface of *land* by broad irrigation.

*Screening.*—Little need be said with regard to the preliminary operation of screening as this may be regarded as essential to all processes of sewage treatment, and the methods adopted need not vary from those usually employed in chemical or land processes of disposal.

*Detritus Tanks.*—Before the sewage enters the septic tank it is very desirable that as much of its suspended mineral matter as possible should be deposited in small detritus tanks from which it can be readily removed, otherwise much more frequent emptying of the septic tank will be needed, and the septic conditions, which take some time to become fully matured, will be needlessly upset. A typical arrangement of detritus tanks adjoining the inlet ends of a pair of open septic tanks is shown in Fig. 1. The depth of the detritus tank should be carried down a little below the floor of the septic tank at its inlet end, as shown in the section

* Interim Report, Vol. II., 1902.

(Fig. 1), and provision made by means of a concrete floor sloping to an outlet valve for the easy removal of sludge and deposit —the same being forced out by the head of water pressure over the outlet valve.

*Septic Tanks.*—The object of the septic tank, as introduced by Mr. Cameron, of Exeter, in the year 1895-6, was "to bring the sewage into such a condition by arresting the solids in suspension as to make the filtration on artificial filters practicable; at the same time taking advantage of the solvent action that goes on in the arrested solids, so as to make the quantity of deposit or sludge as small as possible."

In many towns the strength and composition of sewage varies greatly from hour to hour, and one important function of the septic tank is the equalisation of these variations and the production of a more uniform effluent for subsequent treatment. The sewage in passing through the septic tank is acted on in a way which, according to the experience of many, makes it more amenable to the purifying action obtained in the bacterial filters.

The question of the most suitable capacity of the septic tank, or of the length of time the sewage should be subjected to anaërobic conditions, is one of very considerable importance. It is impossible to lay down any hard and fast rules equally applicable to all cases, as a good deal depends upon the nature, strength and temperature of the sewage to be dealt with. Regard must also be had to the length of time and distance the sewage may have travelled in the outfall sewer before arrival at the site of the disposal works. In the case of a long outfall having little fall septic conditions may be well advanced, and the sewage will have undergone a thorough mechanical disintegration with bacterial decomposition and hydrolysis. Such conditions may well be contrasted with those which obtain in the case of a small works serving a village, mansion or public institution, where the septic tank would be comparatively small and the sewage reaches the outfall in a thoroughly fresh condition within a very few minutes of leaving its source. In such circumstances the tank accommodation needs to be proportionately larger than that required for a large town, where the greater part of the sewage may be several hours journeying to the outfall.

The assumption has been held that the longer the sewage was retained in the septic tank the better would be the final result, but it is now very generally recognised, as indicated above, that it is quite possible to carry the anaërobic change too far. It has been carried to a point at which the nitrification was completely suspended. So far, however, it is not very clearly determined as to when a septic effluent is in the best condition for subsequent purification, or at what stage to arrest or to continue the anaërobic fermentation. The point is one which is receiving close attention.

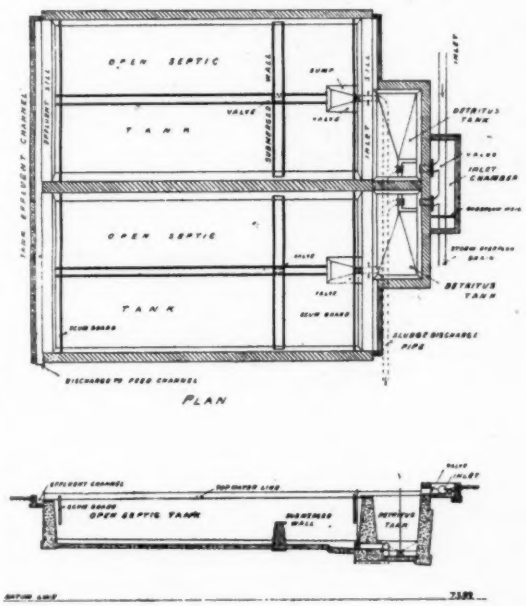



FIG. 1.

An "over-septicised" effluent is usually a very offensive liquid, is liable to cause great nuisance, and is very difficult of subsequent purification.

In practice it would appear that the liquid receives the necessary preparation for subsequent purification on aërobic lines by making the septic tank of such a size as

will admit of the sewage sufficiently approaching a state of rest to allow of the precipitation of nearly the whole of the solids, and also by constructing it of sufficient depth to give space for retaining the same until the putrescible matter has been broken down.

It is interesting to note that for a short term after the introduction of the septic tank the Local Government Board practice was to stipulate for a capacity of 1½ days' dry weather flow. This requirement was subsequently reduced to 1¼ days', and at the present time such capacity need not be more than one day's dry weather flow. The tendency at the present time is in the direction of still further reducing the period of retention in the septic tank, and a capacity of one-half a day's flow is now very commonly adopted in works of the latest design. The septic tanks preceding the bacteria beds at the Sutton (Surrey) sewage works are unusually small and hold only about one-fifth of a day's flow, but appear to be giving every satisfaction.

If, however, the tanks are too small, the rate of flow through them becomes too rapid and the tanks then serve as settling tanks only, and require emptying before septic conditions have time to develop. In fact, the distinction between the working of a septic tank and a settling tank is practically one of rate of flow only.

Further, it should here be mentioned in the present connection, that many new works have been quite recently designed for the dealing with well sedimented sewage upon bacteria beds, with the special object of avoiding septic conditions, and of completing the purification of the sewage whilst it is "fresh." At Leeds recent experiments on these lines have met with much success, and may be taken as emphasising the importance of preliminary experimental work with the particular sewage to be treated, before deciding upon the definite outlines of a large scheme.

In times of rain attention must be directed to the prevention of the rush of storm water through the tanks carrying solids forward to the bacteria beds.

At the Saltley Works of the Birmingham Tame and Rea District Drainage Board the septic tanks have a capacity of about 7¼ million gallons for a sewage flow of about 22 million gallons, so that the stay of the sewage in the tanks is about eight hours only. This is said to be sufficient for the development of septic conditions, but it should also be mentioned that the sewage, after leaving the tanks, enters a large conduit 8 ft. in diameter, which conveys the bulk of the liquid down to the extreme limit of the Board's property. The stay in the conduit is perhaps about six hours, so that at the extreme end the sewage has undergone an anaërobic action of fourteen hours' duration. At the Saltley end the septic treatment would be very short—not exceeding an hour in addition to the treatment in the open septic tanks.

At Exeter, the home of the septic tank, a large amount of storage is provided. The septic tanks, at the combined works, hold 2,358,186 gallons, whilst the joint sewage flow is only 1,295,610 gallons per day—thus giving a septic storage approaching two days' dry weather flow.

Previous to the experiments carried out by the Manchester experts (1899) there was a very general impression that septic tanks must be covered to secure anaërobic conditions, although Mr. Cameron's first idea was to use only open tanks. It is now generally known that anaërobic fermentation goes on quite well in an open tank, especially when a scum has formed on the surface of the sewage, thus providing it with a natural roof which preserves the heat of the liquid below, the scum being a bad conductor. The experience at Leeds showed that whatever results were obtained from the closed tanks were equally well obtained by the open. The average loss of heat of the sewage in passing through the open tank was 1·6° F., and ·8° F. in the case of the closed tank—the difference being too small to warrant the extra cost of roofing.

The advantages which may be set down in favour of the closed tank are shortly these. The roofing maintains a more uniform temperature within the tank, and avoids extremes of heat or cold; the air is excluded and more rapid anaërobic conditions are promoted; the protection afforded by a roof prevents the surface scum from disturbance by wind and rain; the gases given off by the sewage are kept under control, and, if required, can be used for lighting, motive power, or heating; there is less likelihood of nuisance from smell arising from the surface of the sewage as the gases may be prevented from escaping except under control.

Recent experience in the use of septic tanks, both open and closed, goes to show that, unless there is some special local reason to do the contrary, no real advantage is gained by the additional outlay involved in making the air-tight roof; but it is desirable to have some light form of covering, say of galvanised iron, for preventing disturbance by wind and rain of the surface scum. At Manchester, Leeds,

and elsewhere, where careful investigations have been made, the effluents from closed and open tanks have proved to be as near as possible identical both in appearance and chemically.

The inlets and outlets to and from open septic tanks should, of course, be submerged as in the case of the covered tank, and may be arranged by passing the sewage in and out of the tank over a weir behind a scum board to avoid disturbance to the surface scum (see Fig. 1).

The question of smell arising from septic tanks or other parts of a sewage treatment works is one of first importance, especially in some situations. Where the sewage can be kept in a fairly quiet state, an almost entire absence of smell is usually experienced, but all operations involving its movement, such as pumping, mixing, spraying, aërating and such like, result in more or less offensive odours.

An effluent from covered septic tanks sprayed upon percolating filters is much more likely to cause nuisance than an open tank effluent allowed to flow without much agitation into contact beds, the water line of which is kept a few inches below the surface of the filtering material.

As a result of experiments carried out at the Beaumont Leys Sewage Farm, Leicester, it was found that septic tank effluent could not be flowed on to pasture land by broad irrigation without causing a great nuisance.

With covered septic tanks very offensive smells arise when the tanks are emptied for clearing the deposit, and for this reason provision should be made for the removal of as much of the sludge as possible without emptying the tanks. As the septic conditions often take several months to fully develop, the emptying should be postponed as long as possible.

Contact beds, in proper working order, seldom give rise to nuisance from smell. When the beds are dug into the material shows a clean appearance, and presents no smell, except that peculiar to garden soil.

A large amount of gas is given off during the septic fermentation in the tank, and in many cases this has been put to useful purposes. It burns freely and has been estimated to possess from one-half to two-thirds the value of coal gas of 16 candle-power. This gas is not luminous in itself, but becomes so when burnt with an incandescent mantle, and many works are lighted in this way. Experiments have also been made in regard to the use of the gas for power purposes, by burning under a boiler for raising steam, and by exploding in a gas engine. A large amount of gas is evolved from the sewage in this way, but it diffuses freely through the walls (usually of concrete) of the tank, and does not accumulate under pressure in its upper part to the extent one might imagine, owing to the porosity of the walls.

The gas generated in septic tanks consists very largely of marsh gas, which is inodorous. Dr. Fowler (Manchester) found, by a somewhat rough analysis, that the mean of several results came to about 73 per cent. of marsh gas, 6 per cent. of carbon dioxide, and 5 per cent. of hydrogen, and the rest was put down to be nitrogen, 16 per cent.

It is of interest to note, in connection with the Leeds experiments, that severe frost did not interrupt the working of the septic tanks, as there appeared to be no deterioration of the effluent. On one occasion the surface scum was frozen hard enough to bear walking on, but the temperature of the effluent was always well above freezing point.

Widely differing statements are on record as to the proportion of sludge digested in the septic tank. These vary from about 25 per cent. up to as much as 80 per cent. of the total solids entering the tank. At Leicester it was estimated that the reduction of solids in the closed detritus and septic tanks was 83 per cent., and in the open subsidence tank 84 per cent., whilst at Birmingham it was found that practically the whole of the sludge deposited in the septic tanks was dissolved. As against this at the Sheffield Sewage Works the consumption of sludge in the septic tank was estimated at a maximum of 31·9 per cent. In the open tanks at Blackburn the reduction of suspended solids amounted to 72 per cent., and only 38 per cent. at Huddersfield.

The amount of the reduction of the solids obviously has an important bearing on the length of time a tank may be in use without emptying. This in some cases has been as frequent as within twelve-month intervals, whilst in others tanks have been in use five or six years without requiring cleaning. A good deal will depend whether the septic tank proper is preceded by a detritus tank of adequate capacity for the reception of grit and other indigestible materials.

The percentage of moisture contained in the tank residuum varies in different places from 75 up to about 90 per cent. At Leeds, analyses showed that the dry sludge of the open septic tanks lost about 50 per cent. on ignition, leaving about 50 per cent. of ash, about one-third of which was ferric oxide and about half silica. About one-half of

the dried sludge was therefore in a form not further reducible by bacterial action. The sludge from septic tanks is more largely mineral in character, and settles and dries more quickly than chemically precipitated sludge.

As to the important question of the amount of purification effected by the septic tank, the average percentage reductions at Leeds during twelve months' working were — suspended solids 71 per cent.; albuminoid ammonia 61 per cent.; oxygen absorbed 50 per cent.

From analyses made in connection with the Exeter tank, Dr. Rideal has summarised the changes effected by the passing through of the sewage, to the following effect—(1) a marked increase in the total solids in solution or fine suspension; (2) a reduction of about 33 per cent. of the organic matter as measured by the oxygen consumed; (3) an increase of about 33 per cent. in the free ammonia; (4) a reduction of about 54 per cent. in the organic or albuminoid ammonia, or 50 per cent. in the organic nitrogen; (5) a slight production of oxidised nitrogen, and disappearance of a small amount of the total nitrogen. As to the chemical and biological action of the septic tank Dr. Rideal further observes* :—

"It is, therefore, evident that the septic tank, by means of its bacteria, enzymes, or spontaneous chemical decomposition, materially alters the composition of the raw sewage. The increase in the total solids points to a solvent action of the water on matter in suspension, and this may be due to a digestive or to a purely physical process; but the marked disappearance of organic matter, and transference of the nitrogen from the organic condition to that of free ammonia, is undoubtedly due to bacterial influences." . . . "The septic tank seems to effect as much purification as an average chemical precipitation process or as slow upward filtration."

The average percentage of purification on the crude sewage obtained in the Leicester experiments with closed detritus and septic tanks,† was—suspended matter 83·01 per cent., albuminoid ammonia 62·14 per cent., oxygen absorbed at 80° F. in four hours 60.67 per cent. At Birmingham,‡ with roughing tanks and open septic tanks holding about eight hours' dry-weather flow, the percentage of reduction on suspended solids was 63·7, albuminoid ammonia 36·1, oxygen absorbed including suspended matter 29·7 per cent.

The character of the sludge or deposit from the bottom of a septic tank will depend upon the extent to which the mineralisation of the residuum has been carried towards completion at the time of its withdrawal, or whether it contains matter further reducible by bacterial action. The deposit is much more largely mineral than ordinary sludge, and consists of a dark, gritty matter like the humus or peaty substances of soil.

Trial has been made of the use of septic tanks in series—passing the sewage through first one and then a second and third. The first tank is the only one which usually produces a scum, and it also retains the bulk of the deposit from the sewage. The principal advantage of this mode of working is that it facilitates the removal of the deposit, but this is also very readily done by building a submerged wall across the inlet end of the tank and discharging a large proportion of the sludge through a valve in the bottom without emptying the tank.

(*To be continued.*)

## Worm Gearing.

ALTHOUGH much has been written upon the theory of worm gearing some of the most important aspects of the question have received scanty attention, and experimental investigation into the operation of such gearing has been by no means complete. The paper read on the subject before the Institution of Mechanical Engineers by Mr. Robert A. Bruce is not intended to give a complete account of the action of worm gears, but rather to cover some of the more important points that have been omitted from consideration. After discussing and illustrating some profiles of worm teeth, and referring to methods of cutting worm-wheel teeth, the author passes on to consider the nature and extent of the contact taking place between a perfectly formed worm-wheel and worm, and the manner in which the contact is affected by the proportions of these two parts, with the object of developing a theory for determining the proportions of worm gearing. The paper contains a great deal of really valuable matter, and if the author had collated his facts and conclusions in concrete form the practical utility of his contribution would be much more apparent than it is at present.

* Report of Royal Commission on Sewage Disposal (Interim Report, Vol. II., Evidence, 1902).

† Process No. 10, "Leicester Sewage Report," by E. G. Mawbey, M.I.C.E. (January, 1900).

‡ Third Report of Royal Commission on Sewage Disposal, Vol. II., pp. 208 and 209.

# The Properties of Superheated Steam.

PERHAPS the most important problem that has exercised the minds of steam engineers from the earliest days has been the diminution of condensation of steam, with its concomitant evils—increased transference of heat from steam to metal, increased rejection of heat to the condenser, and increased leakage past steam and exhaust valves inside the engine cylinders, which in a modern engine represents as much as from 12 to 30 per cent. of the total steam supplied. Of the various methods employed for the reduction of this condensation, superheating is perhaps the most effective at the disposal of the engineer, and in fact as the limit of efficiency may be stated to have been reached with saturated steam, it constitutes the only known means of effecting further economies.

It is unnecessary here to dwell upon the advantages in practice accruing from the use of superheated steam and the wide application that it is now receiving; what is a matter for astonishment is that our knowledge of its physical properties should be so vague and uncertain in spite of the numerous researches that have been conducted with the object of determining these properties. These experimental results are far from being in agreement, and, in fact, as they continue to be published, the uncertainty as to exactly what are the true physical properties becomes still more emphasised.

Until a few years ago our best knowledge of the specific heat of superheated steam was represented by the results obtained by Regnault, who in his classical series of experiments found the mean specific heat at atmospheric pressure to be 0·48 between 127° and 226° C. of superheat, and this was assumed to be true for a long range of temperatures and pressures.

Hirn, the Alsatian engineer, subsequently conducted a series of experiments with a throttling calorimeter, the results of which showed that the specific heat of superheated steam at atmospheric pressure varied according to the temperature. His results are as follows:—

| Temperatures between which the Specific Heat is taken. | Mean Specific Heat. |
|---|---|
| 260·0 to 263·1 | 0·304 |
| 263·1 ,, 271·4 | 0·674 |
| 271·4 ,, 279·9 | 0·536 |
| 279·9 ,, 287·1 | 0·542 |
| 287·1 ,, 291·4 | 0·787 |
| 291·4 ,, 296·6 | 0·583 |
| 296·6 ,, 301·2 | 0·597 |
| 301·2 ,, 306·5 | 0·925 |
| 306·5 ,, 312·0 | 0·802 |
| 312·0 ,, 314·1 | 0·957 |
| 314·1 ,, 316·0 | 0·930 |

This physicist, however, amplified this conclusion by developing a theory which had for its object to show that the specific heat of saturated steam increased with the pressure; but at a constant pressure, it decreased as the superheating increased.*

Nothing was added to the results obtained by Regnault and Hirn until 1897 when Professor Ewing, in a series of experiments carried out in that year, found that the specific heat increased with the temperature at constant pressure. This result was confirmed by Dr. J. Grindley in a series of carefully made experiments communicated to the Royal Society by Professor Osborne Reynolds in 1900, who found that the specific heat under constant pressure is approximately independent of the pressure, but increases with the temperature. The following is a tabulation of his results:—

| Temperatures. | Mean Specific Heat. |
|---|---|
| 230·7 to 246·5 | 0·431 |
| 246·5 ,, 260·8 | 0·477 |
| 260·8 ,, 269·7 | 0·515 |
| 269·7 ,, 295·0 | 0·564 |
| 295·0 ,, 311·5 | 0·648 |

* *Théorie Méchanique de la Chaleur*, 1876, Vol. ii., p. 201.

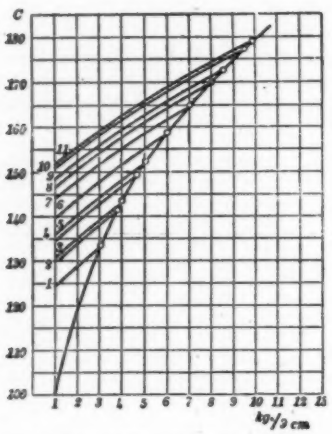



FIG. 1.—THROTTLING CURVES OF GRIEZMANN.

This experimenter used a throttling calorimeter in which saturated steam of from 2 to 14 atmospheres was throttled. This result, however, was contradicted by conclusions drawn by Professor Carpenter from an extensive series of experiments conducted by him in 1891–99, which were to the effect that the specific heat is independent of the temperature for any given pressure and increases with the pressure.

The 1891 experiments were not altogether satisfactory. They were repeated with greater precautions in 1892 and an especially careful set of determinations made in 1900 led Carpenter to the following values.*

| Absolute Pressure. | Specific Heat. |
|---|---|
| 14·7 | 0·484 |
| 20 | 0·492 |
| 40 | 0·523 |
| 60 | 0·553 |
| 80 | 0·563 |
| 100 | 0·614 |
| 120 | 0·645 |

The results may be expressed by an equation in which P = absolute pressure and K the specific heat, as follows: K=0·462+0·001525 P.

Grindley's conclusions received support from the investigations of Griezmann, whose results are given in the accompanying table and figure.†

Professor Lorenz, in a recent series of experiments,‡ on the other hand concludes that the specific heat increases with the pressure, but decreases with an increase of the temperature. This investigator carried out extensive experiments with a view to determining the specific heat of superheated steam for invariable pressures within the limits of temperature and pressure important for industrial applications. The apparatus employed consisted of the following Fig. 2.

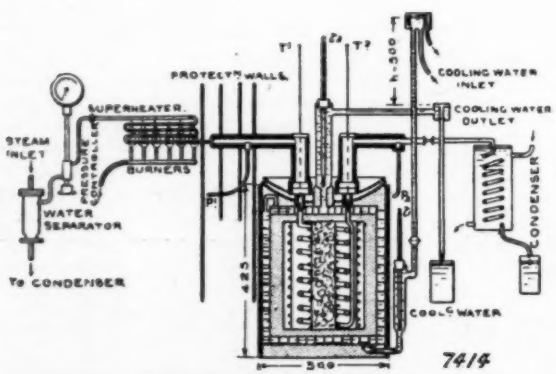



FIG. 2.—LORENZ'S APPARATUS.

Steam after traversing a water separator, enters the superheater through a pressure - reducing valve consisting of a copper tube, 12 mm. in clear width and bent several times, being heated by open Bunsen burners, the number of which may be readily controlled. In the immediate neighbourhood of this superheater, which is

* *Engineering Record*, 50, pp. 83—84.
† *Stevens Institute Indicator*, Vol. xxii., No. 4.
‡ *Zeitsch. Vers. Deutsch. Ing.*, Vol. xlviii., No. 20, pp. 698—700.

TABLE I. GRIEZMANN'S THROTTLING CALORIMETER TESTS.

| Terminal pressure of two curves of Col. 8 Kg/cm. $p$ | Mean pressure at $p$ of two curves of Col. 8 C.° $t_m$ | Range of temperature at $p$ of two curves of Col. 8 C.° $\Delta t$ | Difference of total heat between upper and lower steam pressures. Calories (Regnault). $\Delta\lambda$ | Mean specific heat for range $\Delta t$ (Regnault). $C_p$ | Difference of total heat between upper and lower steam pressures. Calories (Ekholm). $\Delta\lambda$ | Mean specific heat for range $\Delta t$, (Ekholm). $C_p$ | Curves paired to find specific heat. |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1·0 | 138·0 | 27·7 | | 0·513 | | 0·410 | |
| 2·0 | 142·3 | 26·7 | 14.2 | ·532 | 11·35 | ·425 | 1 and 11 |
| 3·0 | 146·1 | 26·3 | | ·542 | | ·433 | |
| 1·0 | 140·7 | 22·3 | | ·511 | | ·398 | |
| 2·0 | 144·9 | 21·4 | 11·4 | ·533 | 8·88 | ·415 | 2 and 11 |
| 3.0 | 148·8 | 20·8 | | ·548 | | ·427 | |
| 1·0 | 141·3 | 21·1 | | ·517 | | ·401 | |
| 2·0 | 145·5 | 20·3 | 10·9 | ·537 | 8·46 | ·417 | 3 and 11 |
| 3·0 | 149·4 | 19·7 | | ·553 | | ·429 | |
| 4·0 | 153·0 | 19·2 | | ·568 | | ·440 | |
| 1·0 | 143·1 | 17·5 | | ·509 | | ·386 | |
| 2·0 | 147·2 | 16·8 | 8·9 | ·530 | 6·76 | ·402 | 4 and 11 |
| 3·0 | 151·1 | 16·3 | | ·546 | | ·414 | |
| 4·0 | 154·8 | 15·6 | | ·570 | | ·433 | |
| 1·0 | 143·8 | 16·0 | | ·513 | | ·388 | |
| 2·0 | 147·9 | 15·4 | | ·532 | | ·404 | |
| 3·0 | 151·8 | 14·9 | 8·2 | ·550 | 6·22 | ·417 | 5 and 11 |
| 4·0 | 155·4 | 14·4 | | ·569 | | ·432 | |
| 5·0 | 158·8 | 14·0 | | ·586 | | ·444 | |
| 1·0 | 145·8 | 12·1 | | ·521 | | ·388 | |
| 2·0 | 149·8 | 11·6 | | ·543 | | ·405 | |
| 3·0 | 153·7 | 11·0 | | ·573 | | ·427 | |
| 4·0 | 157·3 | 10·7 | 6·3 | ·589 | 4·70 | ·440 | 6 and 11 |
| 5·0 | 160·6 | 10.5 | | ·600 | | ·448 | |
| 6·0 | 163·6 | 10·5 | | ·600 | | ·448 | |
| 1·0 | 135·4 | 22·5 | | ·507 | | ·414 | |
| 2·0 | 139·8 | 21·7 | 11·4 | ·525 | 9·33 | ·430 | 1 and 8 |
| 3·0 | 143·8 | 21·5 | | ·530 | | ·434 | |
| 1·0 | 133·9 | 19·6 | | ·495 | | ·405 | |
| 2·0 | 138·4 | 19·0 | 9·7 | ·511 | 7·95 | ·418 | 1 and 7 |
| 3·0 | 142·4 | 18·8 | | ·516 | | ·423 | |
| 1·0 | 131·9 | 15·6 | | ·506 | | ·426 | |
| 2·0 | 136·5 | 15·1 | 7·9 | ·523 | 6·65 | ·440 | 1 and 6 |
| 3·0 | 140·6 | 15·2 | | ·520 | | ·437 | |

protected by asbestos pasteboard, there is placed the calorimeter, containing the steam coil covered with asbestos and surrounded on all sides by a water jacket. In the design of this calorimeter the experience gained in connection with the Junker fuel calorimeter was utilised, a very regular water circulation being obtained by the use of overflow tubes. The thermometers introduced into the steam inlet and outlet tubes (long brass boxes being inserted in the intervals) reached as far as the entering and issuing points of the steam. In order to check the experiments, the two thermometers were exchanged, when no difference was noted. In connection with the water, special checking thermometers were used, divided in tenths of a degree. Before the main experiments were started, the heat exchange of the calorimeter with the surroundings

TABLE 2. LORENZ'S EXPERIMENT.

| No. of Experiment. .. .. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steam temp. above $\tau_1$.. .. .. degs. Cent. | 224·10 | 224·49 | 313·82 | 360·33 | 240·80 | 291·11 | 367·52 | 228·86 | 326·55 | 381·48 | 243·52 | 343·27 |
| ,, ,, below $\tau_2$ .. .. ,, ,, | 190·99 | 190·71 | 244·77 | 281·71 | 203·96 | 232·90 | 260·08 | 181·96 | 262·40 | 296·30 | 161·59 | 244·70 |
| Abs. steam pressure above $p_1$ .. .. kg./sq. cm. | 7·029 | 7·016 | 6·970 | 7·095 | 2·200 | 9·125 | 9·170 | 4·486 | 4·328 | 4·186 | 2·071 | 2·107 |
| ,, ,, below $p_2$ .. .. ,, ,, | 6·629 | 6·616 | 6·670 | 6·795 | 1·735 | 8·730 | 8·870 | 4·136 | 3·778 | 3·686 | 1·793 | 1·671 |
| Boiling temp. above $\delta_1$ .. .. degs. Cent. | 165·31 | 165·45 | 165·16 | 165·88 | 176·71 | 176·35 | 176·56 | 148·18 | 146·84 | 145·64 | 121·70 | 122·25 |
| ,, ,, below $\delta_2$ .. .. ,, ,, | 163·15 | 163·08 | 163·40 | 164·15 | 174·50 | 174·41 | 175·19 | 145·21 | 141·94 | 141·07 | 117·19 | 115·00 |
| Amount of steam in 1 hr. $G$ .. .. .. kg. | 8·270 | 8·214 | 5·992 | 6·276 | 7·132 | 5·821 | 4·136 | 5·648 | 7·676 | 7·068 | 3·206 | 4·632 |
| Water temp. on entering $t_1$ .. .. degs. Cent. | 4·970 | 5·215 | 5·258 | 5·565 | 4·944 | 5·162 | 5·780 | 5·109 | 5·220 | 5·043 | 5·466 | 5·661 |
| ,, ,, issuing $t_2$ .. .. ,, | 13·250 | 13·580 | 16·476 | 18·422 | 14·798 | 16·445 | 19·004 | 13·247 | 17·26 | 20·140 | 13·499 | 18·164 |
| Amount of water in 1 hr. $W$ .. .. .. kg. | 21·680 | 21·518 | 21·327 | 21·455 | 19·506 | 19·818 | 19·604 | 11·560 | 19·430 | 18·226 | 18·290 | 18·260 |
| Water correction $\Delta Q$ .. .. .. heat units. | + 1·47 | + 0·88 | + 0·14 | + 0·60 | — 2·10 | + 0·14 | + 2·28 | — 0·84 | + 5·25 | + 7·63 | — 0·63 | + 4·55 |
| Mean water temp. $t_w$ .. .. .. degs. Cent. | 9·11 | 9·40 | 10·87 | 11·99 | 9·87 | 10·80 | 12·39 | 9·18 | 11·22 | 12·59 | 9·48 | 11·91 |
| ,, air temp. $t_l$ .. .. ,, | 14·16 | 14·81 | 14·07 | 13·55 | 13·80 | 14·46 | 16·05 | 11·67 | 12·93 | 11·80 | 12·94 | 16·54 |
| Air correction $2·4(t_l - t_w)$ .. .. heat units. | — 12·12 | — 12·98 | — 7·68 | — 3·74 | — 9·43 | — 8·78 | — 8·74 | — 5·97 | — 1·71 | + 1·66 | — 8·30 | — 11·11 |
| Absorb heat in 1 hr. .. .. .. ,, | 161·86 | 167·90 | 133·04 | 272·72 | 186·68 | 214·97 | 232·30 | 132·37 | 235·08 | 284·45 | 137·83 | 221·84 |
| Mean steam temp $\tau$ .. .. .. degs. Cent. | 207·55 | 207·60 | 279·30 | 321·02 | 222·38 | 262·00 | 313·80 | 205·41 | 295·00 | 338·89 | 207·55 | 294·00 |
| ,, ,, pressure abs. $p$ .. .. kg./sq. cm. | 6·829 | 6·816 | 6·820 | 6·945 | 8·968 | 8·978 | 8·985 | 4·311 | 4·053 | 3·936 | 1·932 | 1·889 |
| Spec. heat according to equation (1) .. .. | 0·617 | 0·605 | 0·564 | 0·552 | 0·685 | 0·634 | 0·568 | 0·575 | 0·477 | 0·473 | 0·524 | 0·484 |
| Spec. heat according to equation (2) .. .. | 0·640 | 0·625 | 0·572 | 0·558 | 0·710 | 0·646 | 0·571 | 0·591 | 0·491 | 0·483 | 0·538 | 0·500 |
| Mean values of $c$ .. .. .. | 0·622 | | 0·568 | 0·555 | 0·698 | 0·640 | 0·570 | 0·583 | 0·484 | 0·478 | 0·531 | 0·492 |

was ascertained, when 2·4 heat units per hour (independently of the rate of flow of water) were found to be absorbed by the water for a temperature fall of 1° between the water of the calorimeter and the surrounding air. Any necessary corrections of the thermometer readings were made, and the cover of the calorimeter was protected against any heat conduction or radiation from the connecting flange of the steam conduits by means of insulating material in addition to two sheets of asbestos pasteboard. The air layer between the latter was exchanged continuously by means of a strong air current. Readings were made every five minutes, while the cooling water and the steam, condensed in a tube condenser, were weighed every quarter of an hour. The figures given in the table are averages of experiments lasting about 30 mins. to 45 mins. each. The specific heat $c_p$ required may be found from these figures by means of the following equation:

$$c_p = \frac{W\,(t_2 - t_1) - 2{\cdot}4\,(t_l - t_w) + \Delta\,Q_1}{G\,(\tau_1 - \tau_2)} \qquad (1)$$

where $\Delta\,Q$ is the water correction for the accumulation of heat in the calorimeter water (about seven litres), while the remaining letters have the signification stated in the tables. The values thus calculated are recorded in the last line but two of the table. The same specific heats, as calculated in a second approximation from the equation:

$$c_p = \frac{W\,(t_2 - t_1) - 2{\cdot}4\,(t_l - t_w) + \Delta\,Q - 0{\cdot}305\,G}{(\delta_1 - \delta_2)\,G\,(\tau_1 - \tau_2 - \delta_1 + \delta_2)} \qquad (2)$$

where the throttling effect is taken into account, are given in the last line but one. Comparing these results with the corresponding mean steam temperatures, it is seen that the specific heat of superheated steam doubtless increases along with the pressure, whereas starting from the range of saturation a decrease with temperature is noted, as stated by Lusanna (*Nuovo Cimento*, 1896) in the case of carbonic acid. For lower pressures the author's figures obviously approach the amount of 0·48, as found

by Regnault for atmospheric pressures between 128° and 217°; while for higher pressures the figure of 0·60 is confirmed. The objection to Lorenz's method is that it is difficult to control, owing to the impossibility of maintaining the joints steamtight, at very high temperatures, or at those considerably below 200°C, and to the fluctuations of temperature when 350° was exceeded.

The experiments cannot be said to be conclusive, nor did they offer any explanation of the antagonistic results previously obtained.

A more recent research, and moreover one of great interest, is that of Knoblauch, Linde, and Klebe, made at the Physical Laboratory of the Munich Polytechnic. The results obtained by these investigators have been ably set forth in a paper by Prof. Denton contributed to the *Stevens Institute Indicator*.* From this it is gathered that the work of Knoblauch, Linde, and Klebe was primarily devoted to determining the volume of superheated and saturated steam over a sufficient range of pressures and temperatures as would render it possible to deduce a general equation connecting these elements, similar to the Zeuner formula

$$pV = BT - Cp^{\frac{1}{4}},$$

(based upon Regnault's determinations); but they derive the specific heat from a general formula obtained by them. In their endeavour to reconcile the results obtained by Grindley and Griezmann, Prof. Denton proceeds to set forth the argument presented by Knoblauch, Linde, and Klebe.

Specific heat determinations by a throttling calorimeter depend upon the total heat of evaporation of the steam at the upper and lower pressures respectively, and the value of the total heat is taken from Regnault's experiments. The results of these experiments are capable of expression by either of the following :—

$$\text{Total heat} = \lambda = 606{\cdot}5 + 0{\cdot}305t, \text{ or}$$
$$\text{Total heat} = \lambda = 596{\cdot}75 + 0{\cdot}4401t - 0{\cdot}000634t^2.$$

The former value fits the curve that Regnault ran through the plottings of his results, the latter formula fits an equally approximate curve as laid down by Ekholm, and they differ by 10 per cent. of the total heat. Griezmann, whose results are considered to be the better, uses the Regnault formula, and finds the specific heat values in Col. 5 of Table I. But if the equally correct Ekholm formula is applied the specific heats in Col. 7 result, and then *the specific heat at any one pressure decreases with the rise of temperature and increases with the pressure*, as clearly as any opposite variation is exposed by the values of Col. 5. . . . In other words the 1 per cent. of possible error in the Regnault values of total heat can distort the law of variation of the specific heat with pressure and temperature, because this law depends upon differences of specific heat which represent only 0·1 to 0·2 per cent. of the total heat. The throttling calorimeter is therefore not available to investigate the law of variation of the specific heat with sufficient nicety to discriminate between the influence of pressure and temperature, because the absolute value of the total heat of evaporation is not accurately enough known.

In their experiments, Messrs. Knoblauch, Linde, and Klebe operated as follows :—

A boiler $K$, fig. 3, with a gas fire, supplies a vessel $A$ with saturated steam, which surrounds a glass balloon $B$, terminating in a glass tube, or neck, $C$ $D$, joined at $D$ by a stuffing box to the tube $L$ $F$ $G$ leading to the mercury reservoir $M_1$, of a manometer $M$. Surrounding the neck of the balloon is a chamber $H$ $H$, with a glass window. This chamber opens into $A$ at the top, and is drained free from water of condensation at the bottom, by the pipe $L$ $N$ $O$ leading back to the boiler. A second chamber, $Q$ $Q$, connects by $R$ to $A$, and is drained back to the boiler, under control of the stop-cock $h_0$. In this second chamber lies a glass tube $S$ open at the top, and also connected through the stuffing-box $u$, with the manometer column at $F$.

Suppose a known weight of water placed in the balloon, and the volume of the latter to be confined to that corresponding to a certain level $H$ $H$, at which the mercury in in the neck is to be maintained. If the water is evaporated into exactly saturated steam, we can find from the steam-tables the pressure, $p$, and temperature, $t$, which this saturated steam must have in order that the given weight shall occupy the given volume. Suppose $p$ is 100 lbs. per square inch absolute, so that $t$ is 328° Fahr.

* Vol. xxii. No. 4.

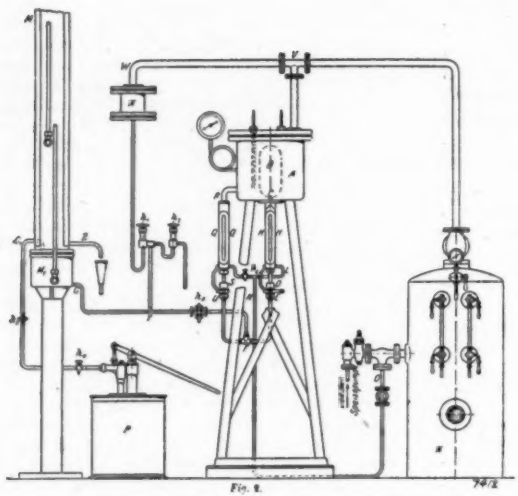


FIG. 3.—APPARATUS USED BY KNOBLAUCH, LINDE, AND KLEBE.

If we now superheat the balloon steam at constant volume by using in $A$, saturated steam of 335° this steam will be at 110 lbs. pressure, but the balloon steam cannot be under a pressure quite so high.

$$p' = 100\,\frac{335+461}{328+461} \text{ or } 101 \text{ lbs.}$$

Because this would be the pressure for a perfect gas-like air in the balloon instead of steam, and we know that any imperfect gas, like superheated steam at constant volume, does not increase in pressure as much as air for a given increase of temperature. If, therefore, we have both the superheated steam in the balloon and the saturated steam in $A$ connected to the *same* mercury-column, the level in the wet-steam leg $Q\ Q$ must be *below* the level $H\ H$ in the superheated leg, so that the height of the mercury-column, measured from the $Q\ Q$ level, will show the 110 lbs. pressure of the saturated steam, while the height, measured from $H\ H$, will show the 101 lbs. pressure of the superheated steam.

This is the idea applied, to discriminate between the saturated and superheated conditions, in the apparatus of Fig. 3. For each weight of water placed in the balloon the saturated pressure, and its temperature, are computed from the steam-tables for a prescribed level or mark $H\ H$, which is made to adapt itself to any pressure by controlling the level of the mercury in the reservoir $M$ with the hand-pump $P$. Further means of adjustment are also provided by the reservoir $X$, from which mercury may be forced into the system by steam pressure, and also by the valve $h_1$, which permits mercury to be withdrawn. The temperature of the saturated steam in $A$ is then raised above this calculated temperature *with the level H H maintained constant.* This secures the maximum amount of superheating to be used in the experiment, and the temperature and pressure in the balloon being noted, the known volume and weight determines the corresponding density of the superheated steam. The level in $Q\ Q$ is then far below $H\ H$, but is of no consequence, until by gradually lowering the temperature in $A$, this level ceases to approach that in $H\ H$. When this occurs the saturated condition has been reached. The same density belongs to all the pressures and temperatures observed between the initial superheated condition and the final saturated condition, for each weight of water placed in the balloon.

The observations made are shown in Fig. 4. Each of the numbers 1, 2, 3, &c., to 32, along the main curve represents an experiment, for which the abscissa and ordinate of the number are the observed temperature and pressure of a given balloon volume of saturated steam, and the inclined line, extending to the right from each number, shows the rise of pressure with temperature for the *same volume* of superheated steam. It is evident from this chart that the difference of the pressure of the saturated steam, due to a few degrees rise of temperature, is so much greater than that of the superheated steam that the difference of the levels $Q\ Q$ and $H\ H$ is a very accurate means of discriminating between the saturated and superheated conditions.

To eliminate air from the balloon the following very ingenious method was pursued: The balloon was washed, first with nitric acid, and then with distilled water. It was then dried, by blowing warm air into it, and heating it for several hours in a drying oven. An amount of water (from 1·5 to 12 grams) was then lodged in a glass tube, and the whole weighed; it was then inserted by a wire, and the tube withdrawn and weighed after the water had been

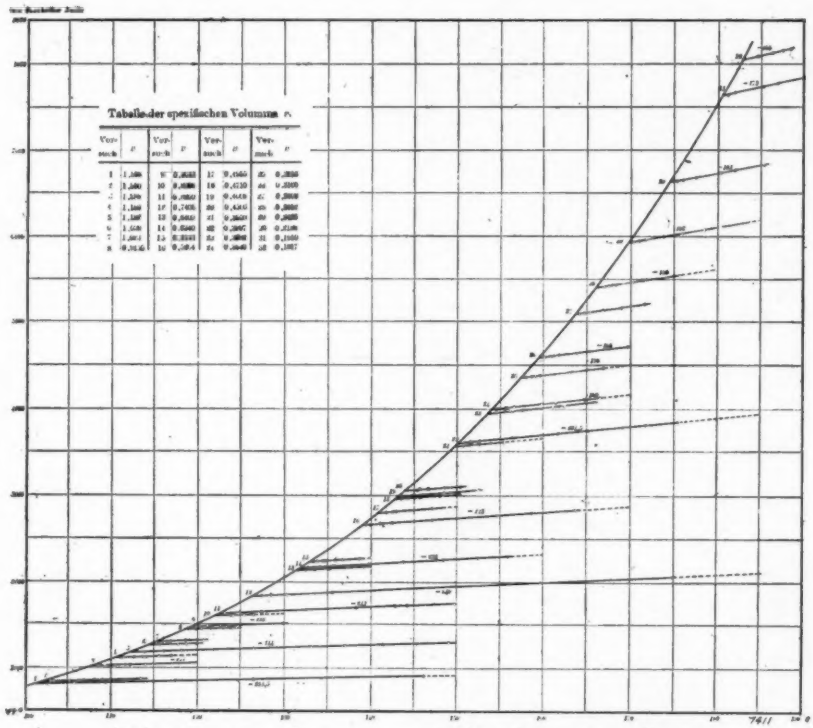



FIG. 4.—CHART OF OBSERVATIONS MADE WITH APPARATUS SHOWN IN FIG. 3.

emptied from it. The balloon was then packed in a bag of carbonic-acid snow and the water frozen, while the neck of the balloon was connected to the atmosphere through a chloride of calcium air-drying tube. The balloon with its bag of $CO_2$ was then put into place in the vessel $A$, and exhausted of air by a pump to within half a millimetre of a perfect vacuum. Tests were made to prove that no sensible loss of the water-charge occurred, by evaporation from the ice, during the exhaustion, by drawing the air through phosphoric-acid anhydride and determining the water-vapour absorbed.

The design of the experiments was to improve upon the results of Battelli,* the most extensive previous experimenter in the measurement of steam-volumes, by using about ten times the quantities of water in the evaporating vessel, so as to reduce the error due to surface action, and, by a more accurate discrimination between the saturated and superheated condition, Battelli having relied upon the visible evidence of condensation, upon a mirror in his balloon, as the superheating was gradually reduced, to fix the beginning of the saturated condition. The pressures found for the boiling-point of saturated steam are less than those found by Regnault in 1850 by from 0 to $\frac{1}{4}$ per cent. between 100° and 140° C. and by $\frac{4}{10}$ per cent. between 140° and 180° C. Battelli's pressures averaged $\frac{5}{10}$ per cent. in excess of Regnault's to 140° C., and $\frac{4}{10}$ per cent. below them from 140° to 180° C. The volume per unit of weight for saturated steam exceeds those in the standard steam-tables, which are calculated from Regnault's values of latent heat by the second law of thermodynamics,

* A. Battelli, *Memorie della reale accademia della scienze di Torino*, 1893. Abstract *Annales de Chimie et de Physique* (7), 3, S., 408, 1894.

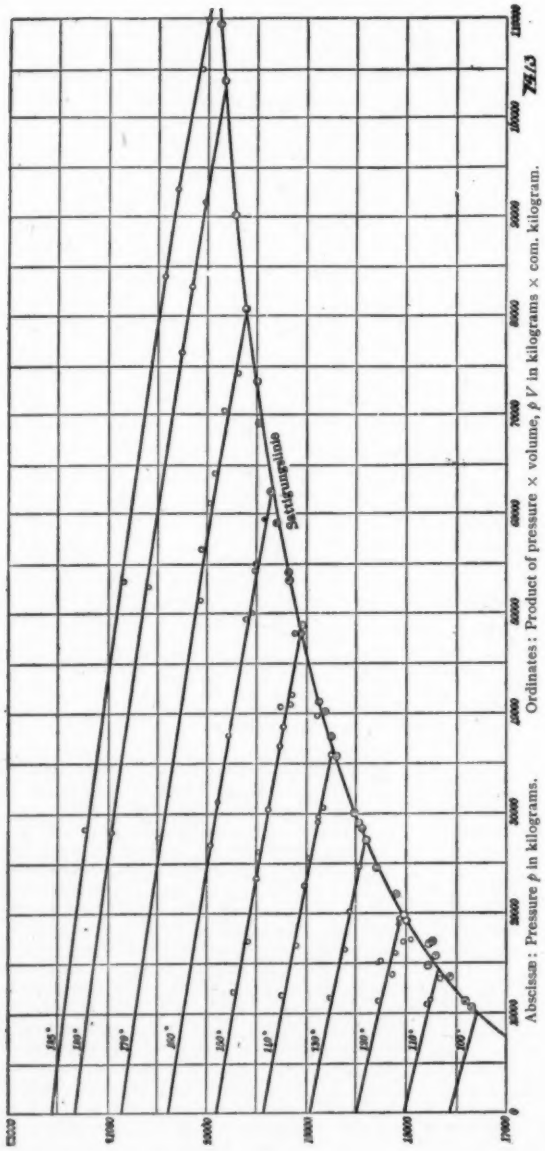



FIG. 5.

by an average of about 1½ per cent. with a maximum variation of 2 per cent. between 100° and 180° C. Battelli's volumes are from ⅓ to ⅛ per cent. less than those found at Munich up to 140° C., and then run to three per cent. above the latter up to 180° C. With these experimental data in hand, plottings were made of the results as shown in Fig. 5, with the product $pV$ as an ordinate and $p$ as an abscissa, these co-ordinates being the most convenien for use in discovering an empirical formula to represent the relation between pressure, temperature, and volume. The formula finally adopted as representing all the observation with satisfactory accuracy was:

$$pV = BT - p(1+ap) \left[C\left(\frac{373}{T}\right)^3 - D\right] \quad . \quad . \quad . \quad (A)$$

$p$ = pressure, kilograms per square metre.
$V$ = volume of a kilogram in cubic metres.
$T$ = absolute temperature, degrees centigrade.
$B = 47{\cdot}1$. $a = 0{\cdot}000002$.
$C = 0{\cdot}031$. $D = 0{\cdot}0052$.

From this formula are calculated both the saturated curve and the superheated constant-temperature lines of Fig. 5.

It is to be noted that the latter are slightly concave to the base-line. The similar lines for Zeuner's formula $pV = BT - Cp^{\frac{1}{4}}$ are convex to the base-line which shows the incorrectness of this historical equation, although it agrees with the few experimental volume determinations of superheated steam by Hirn, existing when Zeuner established it. The general equation $A$ is applied by Messrs. Knoblauch, Linde, and Klebe to calculate the latent heat of

evaporation of the saturated vapour by means of the formula:

$$\text{Latent heat} = r^* = \frac{uT}{J}\left(\frac{dp}{dT}\right).$$

$T$ = absolute temperature of the boiling-point.
$J$ = Joule's equivalent.
$u$ = volume of unit weight of vapour less the volume of its liquid.

$\left(\frac{dp}{dT}\right)$ = the partial differential coefficient of $p$ (volume constant) from equation $(A)$. The results exceed Regnault's experimental latent-heat values by from $\frac{4}{10}$ to $\frac{7}{10}$ of one per cent.

This formula represents the hypothesis known as the Second Law of Thermodynamics, applied, by pure mathematics, to calculate the work of expanding water into steam. If therefore this second law is competent to afford the means of correctly calculating the heat which is absorbed in overcoming the great internal attractive forces, between the molecules, which cause the existence of the latent heat of evaporation, it is reasonable to expect the law to be reliable to calculate the heat absorbed to continue the expansion of the saturated vapor into the superheated condition, where the internal attractive forces are of the same nature as those existing during evaporation, but, relatively, of very small magnitude. The heat thus absorbed, for expansion at constant pressure, divided by the range of temperature produced constitutes the mean *specific heat at constant pressure*. Such a calculation results in the following formula for the specific heat at constant pressure for an infinitesimal range of superheating $dT$:

$$C_p = \frac{1}{J}\,\frac{X}{X-1}\,p\left(\frac{dV}{d\tau}\right).$$

$J$ = Joule's equivalent.
$X$ = The exponent in a formula, $pV^x$ = constant, as the law of an adiabatic curve for superheated steam.

$\left(\frac{dV}{d\tau}\right)$ = the partial differential coefficient of $V$ (pressure constant) from Eq. $(A)$, which is a finite quantity. This is established by accepting the truth of the second law, and two assumptions, and then, by pure mathematics, there results the following value for the mean specific heat at constant pressure for a given finite range of superheating:

$$\left.\begin{matrix}\text{Mean Specific Heat}\\ \text{Between } T_1 - T_2\end{matrix}\right\} C_m = \frac{1}{J}\,\frac{X}{X-1}$$
$$\left\{B + \frac{373}{T_1 - T_2}\left[p(1+a\,p)\,C\left(\frac{1}{T_2^3} - \frac{1}{T_1^3}\right)\right]\right\}$$

$J$ = Joule's equivalent (metric) = 427.
$X$ = 1·309.
$B$ = 47·1.
$T$ = Absolute temperature centigrade.
$p$ = Absolute pressure kilograms per square metre.
$a$ = 0·000002.
$C$ = 0·031.

The assumptions involved are, that any adiabatic curve for superheated steam will be represented by the formula $pV^x$ = constant, and that $X$ = 1·309 (based on experiments* of Hirn and Cazin, whereby $X$ was determined by the flow of gas from one vessel to another with $p$ = 4·5 atmospheres and 200° of superheat) is constant for all pressures and degrees of superheating. Substituting the constants we therefore have:

$$C_m = 0{\cdot}00991\left\{47{\cdot}1 + \frac{1}{T_1 - T_2}\right.$$
$$\left.\left[1508749\,p\,(1+0{\cdot}000002\,p)\left(\frac{1}{T_2^3} - \frac{1}{T_1^3}\right)\right]\right\} \quad . (B)$$

Messrs. Knoblauch, Linde, and Klebe apply this formula to Regnault's range of 127° to 227° at atmospheric pressure for which he obtained a value $C_m$ = 0·48, and find the calculation to give $C_m$ = 0·479.

In Table III., Professor Denton has computed the values of $C_m$ from this formula, for a few of the boiler pressures of practice, between the boiling-point and three ranges of superheating.

$$C_m = 0{\cdot}00991\left[47{\cdot}1 + \frac{1}{T_1 - T_2}\right.$$
$$\left.\left\{1608749\,p\,(1+0{\cdot}000002\,p)\left(\frac{1}{T_2^3} - \frac{1}{T_1^3}\right)\right\}\right]$$

$T$ = Absolute temperature centigrade.
$p$ = Pressure kilograms per square metre.

TABLE 3 (page 110).

MEAN SPECIFIC HEAT BY FORMULA.

* Peabody's *Thermodynamics*, Eq. 128.

* Hirn's *Theory of Heat*, Vol. i., p. 110, and Vol. ii., p. 243.

TABLE 3.—MEAN SPECIFIC HEAT BY FORMULA.

| Absolute Boiler Pressure. | | Boiling-Point $t_2$ C°. | Mean Specific Heat at Constant Pressure. $C_m$. | | |
|---|---|---|---|---|---|
| | | | Range of superheating. | | |
| Lbs. per sq. in. | Kilograms per square metre. | | 10° C. | 50° C. | 100° C. |
| 99·48 | 69,958 | 164 | 0·567 | 0·551 | 0·537 |
| 139·32 | 97,978 | 178 | ·597 | ·577 | ·559 |
| 190·70 | 134,106 | 192 | ·634 | ·609 | ·586 |
| 266·20 | 187,158 | 208 | ·686 | ·656 | ·626 |

## H.M. Fleet Scout "Attentive."

TOWARDS the close of the year 1901, the British Admiralty determined to acquire a number of vessels of a new type to be designated "Fleet Scouts." The conditions associated with their design and construction constituted an important departure from long standing Admiralty practice, according to which the dimensions, horse-power, speed, armament, and all other important features and details of vessels intended for His Majesty's Navy, have hitherto been arranged and decided upon by the constructive staff of the Admiralty, at present presided over by Sir Philip Watts, K.C.B. Under this system, the talent and resources of private firms were left out of consideration, leaving the responsibility for success or failure entirely dependent upon their capabilities and experience in the mechanical process of construction only. The advantages of this method of procedure are obvious; it must necessarily be affiliated with any scheme having as its objective the creation of a fleet of battleships and cruisers embodying uniformity in material and construction, and the greatest possible interchangeability of the several parts.

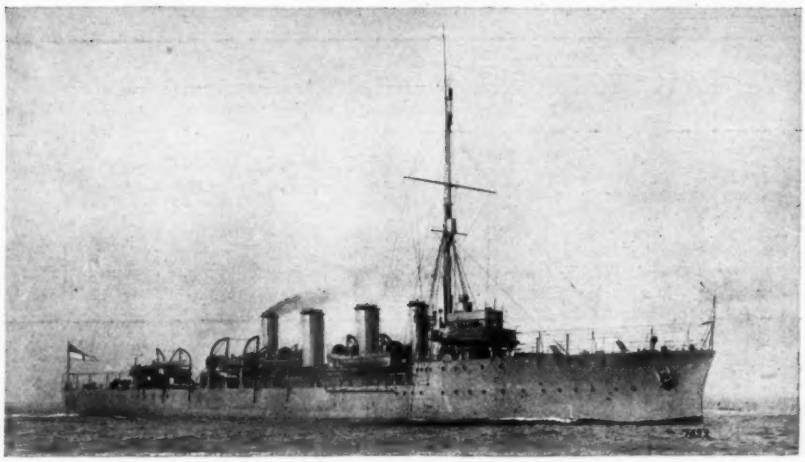
The conditions stipulated by the Admiralty in connection with the experiments of building these scouts gave to the leading firms in the country a free hand in the attainment of certain requirements specified by the Admiralty, thereby putting to the test both the scientific and practical skill of the shipbuilder and engineer, so that the Admiralty in each case obtained the best each firm had to offer. Thus the departure from established British Admiralty usage, involved consideration by the contractor of such questions as form, power, loads, &c., culminating finally in a test of speed under certain specified conditions.

Preliminary enquiries by the Admiralty of the leading firms in the country resulted in the selection of a design submitted by each of the four following firms:—Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick; Cammell, Laird & Co., Birkenhead; The Fairfield Co., Glasgow; and Vickers, Sons and Maxim, Ltd., Barrow.

Each of these firms was entrusted with the task of designing and constructing a vessel having satisfactory sea-going qualities, suitable accommodation for officers and crew, stores armament, ammunition, &c., and of a certain minimum speed.

The new vessels may be described as representing the torpedo boat destroyer enlarged and developed. It was considered that the procedure indicated above in reference to their design and construction would elicit from each of the firms named the best examples of the type which they were respectively capable of producing. The result demonstrated not a little variety of judgment on the part of the selected firms as to the size, form and displacement best calculated to achieve the requirements insisted upon by the Admiralty, particularly in regard to speed, endurance, sea-worthiness, &c. For instance, the lengths of the vessels represented by the four designs submitted, varied between 374 ft. and 360 ft., the beams ranged from 40 ft. to 38 ft. 3 in., and the drafts from 13 ft. 10½ in. to 12 ft. 6 in., whilst the displacements ranged from 2,620 tons, representing the lowest, to 3,060 tons, representing the highest, and the horse-power developed on the trials varied from 14,300 to 17,500.

The general appearance of the *Attentive* is indicated by the accompanying photograph. She has a top gallant forecastle and flaring bows. A single pole mast is



H.M.S. FLEET SCOUT "ATTENTIVE."

used for signalling purposes only, and there are four short funnels. The vessel resembles generally, though on a larger scale, the latest type of torpedo boat destroyer.

The length of the vessel has enabled her builders to provide large roomy cabins and accommodation for officers, crew and stores.

The coal bunkers have a capacity of upwards of 450 tons.

The armament consists of ten twelve-pounder 18 cwt. quick-firing guns, eight three-pounder quick-firing guns, and two eighteen-inch above water torpedo tubes.

The vessel is electrically lighted throughout, and all the fans, except those in the stokehold, are driven electrically.

The designs of the first four scouts having been agreed upon, each firm was given the order to duplicate its design, so that eight vessels of this class have been constructed, two by each of the firms already named.

The last of the eight vessels—H.M.S. *Attentive*, built by Sir W. G. Armstrong, Whitworth & Co.—has just recently completed her official trials, and it may be mentioned that the results of the trials of the several vessels have been as variable as those arrived at and embodied in the designs of the vessels. The highest speed obtained on the 6½ hours' full power speed trial of all the vessels was that attained by the *Attentive*, namely, 25.88 knots. This speed places the *Attentive* in advance of any of the other seven scouts, and gives her an advantage of half a knot per hour over H.M.S. *Adventure*, also constructed by Messrs. Armstrong, Whitworth & Co., at Elswick. Moreover, the speed of the *Attentive*, which was sustained during the full period of 6½ hours, probably places and establishes this vessel as the fastest, other than destroyers, in the world. A noteworthy feature in connection with the full power trial of the *Attentive* is revealed by the fact that throughout the last hour of the trial she maintained the remarkable speed of 26¼ knots. This splendid result coming as it did at the concluding hour of an onerous trial, reflects great credit upon the efficiency of the boiler equipment of the vessel.

The *Attentive* and the *Adventure* are identical in every respect, except as regards the propellers, and the superior speed of the former is attributed to a slight difference in the screws. After the trials of the first of the Elswick vessels (the *Adventure*) were completed, her designers felt convinced that she was capable of even better results than those attained, and in order to satisfy themselves on this point, a lengthy series of experiments were conducted to determine whether propellers of better and more suitable proportions were obtainable for the second vessel than had been secured in the first. The result of these experiments is shown by the magnificent performance of the *Attentive*, and the wisdom of the

DETAILS OF FULL-POWER TRIAL, 12TH DECEMBER, 1905.

| | 6½ Hours | | | | | | |
|---|---|---|---|---|---|---|---|
| | ½ hour. | 3rd hour. | 4th hour. | 5th hour. | 6th hour. | 7th hour. | 8th hour. |
| Steam in boilers, lb. | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| Steam at engines, lb. | 242 | 240 | 240 | 240 | 242 | 245 | 245 |
| Air pressure in stoke-holds, in. ... ... | 2·3 | 2·8 | 3 | 3 | 3·1 | 3·2 | 3·1 |
| Vacuum, in. ... ... | 25·25 | 25 | 25 | 24·75 | 24·75 | 24·75 | 24·5 |
| Mean revolutions ... | 251·4 | 256·9 | 257·25 | 257·65 | 257·55 | 256·85 | 260·6 |
| Indicated horse-power | 14,939 | 16,416 | 16,217 | 16,512 | 16,100 | 16,292 | 16,879 |
| Speed ... ... ... | 25·283 | 25·836 | 25·87 | 25·91 | 25·91 | 25·83 | 26·2 |

designers and builders of the vessel in carrying them out, notwithstanding the expense they must have involved, has been confirmed. Detailed results of the trial of the *Attentive* are given in the above table, in explanation of which it should be pointed out that the specified period of the trial is eight hours, the first 1½ hours being occupied in making runs over the measured mile to determine the relationship between speed and revolutions; the subsequent six and a half hours steaming constitute the speed trial proper.

The engines and boilers of both the *Adventure* and *Attentive* have been designed and constructed by Messrs. Hawthorn, Leslie & Co., St. Peter's Works, Newcastle-on-Tyne, and are exact duplicates of each other. The engines of all the vessels are of the ordinary reciprocating type.

The propelling machinery of the *Adventure* and *Attentive* consists in each case of two sets of twin-screw vertical direct-acting engines, each set having two high, two intermediate, and two low pressure cylinders.

The boilers, twelve in number, are of a modified Yarrow type.

It may be stated that in addition to the full power trial referred to above, these vessels have been subjected to various other tests, including an endurance trial of 96 hours at cruising speed. Both in the full power trial and in the endurance trial the vessels have exhibited excellent sea-going qualities.

The Admiralty is therefore to be congratulated upon the acquisition of these vessels as a valuable addition to the British fleet, and the builders of them are to be congratulated also upon the remarkable success of their design.

## Pressure drop through Poppet Valves.

RECOGNISING the universal use of the poppet valve for gas engine work, as well as its growing use for steam engines, C. E. Lucke, in a recent paper before the American Society of Mechanical Engineers,* here details a series of experiments carried out to determine the pressure drop through such valves under varying conditions of working. The tests were carried out both with flat and with conical-seated valves—with steady flow through the valve, and with intermittent flow such as generally occurs in gas engine work—and also with flow in both directions through valve. The flat valve was 1⅝ ins. diameter, while two conical valves having inside diameters of 1½ in. and 2 in. were used. Pressures were measured by water column, and volumes of air passing valve by meter. Assuming the theoretical velocity of efflux to be given by $V = \sqrt{2gh}$., as is approximately true for these small differences of pressure, the author calculates in each case the "co-efficient of efflux," *i.e.*, the ratio $\frac{\text{Actual Velocity}}{\text{Theoretical Velocity}}$. With steady flow through the flat valve with lift of ·05, ·10, ·15, and ·20 in., this co-efficient diminishes from ·80 to ·61 as the lift increases from ·05 to ·20 in. Also, in general, the co-efficient diminishes as the pressure drop, and hence velocity of efflux increases. With the conical valves and the same lifts as before, the co-efficient is greatest when the valve has ·10 in. lift, and seems in general to be independent of

* Transactions, vol. xxvii.

the velocity of efflux, varying from ·99 with ·10 lift to ·85 with ·20 in. lift.

In the tests carried out with an intermittent flow through the valves, these were regulated either automatically or by cams. With automatic opening, the magnitude of this was regulated by suitable stops to be either ·05, ·10, ·15, or ·20 in. With the $1\frac{5}{8}$ in. flat valve the best results were obtained — using the valve as a suction valve—when the maximum lift was ·15 in., the volumetric efficiency of the cylinder being greatest in this case. The percentage loss in volume of air drawn into cylinder varied from 4 per cent. with ·15 in. lift to 9 per cent. with ·05 in. lift, being slightly over 4 per cent. with ·20 in. lift, these being mean values. The actual value, however, depends largely on the speed of the engine.

With cam regulation and conical seated suction valve 1·5 in. diameter, the mean lift being ·226 in., the loss in volume became as high as 25 per cent. at speed of 300 revolutions, while with a 2 in. conical valve, having a mean lift of ·393 in., and passing the same volume of air, the loss was 9 per cent. at the same speed.

Pressure drop and volumetric efficiency depend largely on form of opening and of approach and exit, as well as on speed of engine. Conical seated valves in general seem to give better results than flat valves, and automatically regulated suction valves than cam regulated valves.

## The Problem for Locomotive Engineers.*

Of late years the problem before locomotive engineers has been how to increase the hauling capacity and speed of their engines. The traffic has increased, both in passengers and goods, and such additional provision has been made for the accommodation and comfort of passengers that the weights of these trains are now much greater, in proportion to the numbers they carry, than they were even a few years ago. The question naturally arises, "Has anything been done to ease the running of the load?"

* Abstract of a paper on "The Steam Locomotive Fifty Years Ago and Now," read by Mr. S. Rendell, M.I.Mech.E., before the Manchester Association of Engineers.

Since D. K. Clark's experiments, the results of which were published in his "Railway Machinery" in 1855, something has been done to diminish the train resistance per ton of load by improved designs of axleboxes, with oil lubrication instead of railway grease, thereby reducing the axle friction from about 6 lbs. per ton to between 3 and 4 lbs. at slow speed, the resistance rising as the speed increases; and some companies are trying roller bearings on their coaches, the result being still more favourable, with the additional advantage of very little perceptible wear.

It may be noted in passing that, so far as the wheels themselves are concerned, no doubt the *rolling* friction has been reduced in the last fifty years, by the general use of steel for tyres and rails, much harder and more durable than the iron of which they used to be made; but this can only be a small item.

The reduction of axle friction is quite in the right direction, and would be most effective if railways were, as a rule, of such a "first-class" nature as to be absolutely level and straight, a condition approximated to in a few countries only, as, for example, the Netherlands. Generally speaking, on any railway in our own island, gradients, though not in many instances severe, are frequent, and curves are numerous.

The locomotive is required to haul its train through all these, in all kinds of weather, to its destination, and keep scheduled time, with perhaps the assistance of a pilot engine on a specially steep bank, the tendency being to discard even this. In addition to overcoming axle friction there must, therefore, be power enough to lift the load up the stiffest incline and drag it round the sharpest curve, the two sometimes occurring in combination.

The effect of gravity against ascending an incline is strictly = load × sine of angle, but as the angle is small, the sine is practically equal to the gradient. For a gradient of 1 in 100, or $\frac{1}{100}$, the resistance due to gravity is $\frac{2,240}{100} = 22{\cdot}4$ lbs. per ton. For $\frac{1}{50}$ it is $\frac{2,240}{50} = 44{\cdot}8$ lbs. per ton, and so on. It is at once evident that, in comparison with axle friction, we have here something more formidable, and which *does not admit of reduction*.

When a train runs through a curve, especially if it be a reverse, or S, curve, a large amount of resistance arises through the wheel flanges grinding against the

inside edges of the rails, and the collars of the axle journals being forced over against the ends of the bearings, thus developing end friction.

Curve resistance depends upon the radius of the curve and the length of rigid wheel-base of the vehicles. It is a rather uncertain quantity, varying also with the wind, and with the state of the rails, whether dry or greasy. For example, with vehicles of 12 ft. rigid wheel-base, on a curve of 1,500 ft. radius, it will probably be from 1½ to 3½ lbs. per ton; on a 1,000 ft. curve, from 2 to 5 lbs. per ton. With a shorter wheel-base the resistance will be somewhat less.

During the latter half of the past half-century, curve friction has been reduced by making better arrangements for end wear, and by ampler lubrication. Much has also been accomplished by the more general adoption of bogies. A vehicle with a long rigid wheel-base is very unsuitable for working over sharp curves, because the wheel flanges meet the rails at an angle, not only "grinding" badly, with consequent flange wear, but also tending to "mount" and leave the track.

For this reason, on modern rolling stock, short-based bogies, although heavier and more expensive than fixed axles, are used for long vehicles. A bogie is free to set itself on the rails, thus materially diminishing the curve resistance. Two bogies, each having either two or three axles, will carry a very long and heavy vehicle.

The atmosphere tells against high speed, and wind has great effect in increasing train resistance. A head wind virtually increases the rate at which the train is rushing through the air. A wind not dead in front, but inclined to one side, is still more detrimental, in that it produces the additional effect of forcing the vehicles to one side, causing an action similar to that on a curve. The wedge-shaped projections, or "wind-cutters," seen on some Continental locomotives, are probably of little use.

Among other things that may militate against high speed are badly-balanced wheels and the fan-action of wheel spokes. In this respect the passenger coaches of to-day, with their carefully-balanced built-up wooden disc wheels, are an improvement on those of fifty years ago.

A further cause of retardation, not often noticed, is that, in rounding a curve, the wheels are like so many gyroscopes, each endeavouring to keep to its own plane of rotation, and producing an increased pressure between the curved rail and the wheel flange, thus entailing the absorption of additional power when running at high speed.

The past half-century has seen a great increase in axle-loads, owing to the use of heavy steel rails. The first Bessemer steel experiments were made at Galloway's Knott Mill Iron Works in 1856, and the author was informed that the first Bessemer steel rails were rolled from some ingots of this steel at the Pendleton Iron Works, and laid on the Manchester and Bolton section of the Lancashire and Yorkshire Railway, where they did good service for many years. It was, however, a long time before the old iron rails were generally replaced by steel, mainly because of the high price of the latter in those early days.

The maximum safe axle-load in tons on a steel rail of ordinary section may be simply obtained by dividing the weight of rail in pounds per yard by five. Thus, a 60 lb. rail should be good for 12 tons per axle, an 80 lb. rail for 16 tons, and a 100 lb. rail for 20 tons.

With "single" engines the adhesion weight, with 100 lb. rails, is therefore limited to 19 or 20 tons. Slipping is not uncommon at starting, even with steam sanding apparatus, and great hauling capacity is impossible. For this reason these engines have given place to those having two axles, or four wheels coupled; while in some cases six wheels coupled are in use for heavy passenger trains, and goods engines have now invariably either six or eight wheels coupled.

Fifty years ago a very large driving-wheel was looked upon as a necessity for high speed. The general tendency now is to rely more on an increased number of revolutions per minute than upon unusually big wheels.

The difficulties in the way of putting a fair-sized engine upon a narrow-gauge railway, are now fast beginning to appear in ordinary 4ft. 8½in. gauge work, with this difference, that on the ordinary gauge the difficulties are accentuated by the fact that the space allowed outside the rails is less in proportion than for narrow gauges.

Large cylinders are not easily got inside, because of the limited space between the frames, and may not be possible outside, because foul of station platforms, bridges, and tunnels. Large boilers require large grates, and consequently long fireboxes, and often, after the boiler centre has been pitched at such a height that the chimney must be made ridiculously short to avoid being knocked off by bridges and tunnels, there is still trouble in getting a satisfactory firebox and ashpan, clear of the axles and

wheels which are underneath and on each side of them.

*The Locomotive Boiler.*—Referring now to the locomotive boiler, larger diameters and higher pressures, without great increase in weight, have been made possible by the use of mild steel plates, and by improved construction in the way of heavier jointing and more elaborate staying. The late Mr. Daniel Adamson introduced the use of steel for locomotive boilers about 1857. It is not yet exclusively used, a few still preferring to pay for Yorkshire iron, when the pressure desired is not high.

The difficulty of staying the roof of a long round-topped firebox, without the addition of heavy girders or other objectionable device, is solved in the "Belpaire" firebox, first introduced long ago by M. Belpaire on the Belgian State Railways, where grates of large area were required to consume poor fuel.

The shell of this box has flat sides and top, the sides being stayed together by transverse through stays, and the top stayed to the inner crown by vertical through stays, some arrangement being made over the tube plate to allow of its free expansion. Further advantages are good steam space and the ease with which the crown can be washed through plug holes along each side of the outer shell.

The early "Belpaire" fireboxes were of iron, the flanged plates being slowly worked on hand blocks. The advent of the hydraulic flanging press, and the more general use of steel plates, much simplified the flanging operation, and now "Belpaire" boxes are commonly used.

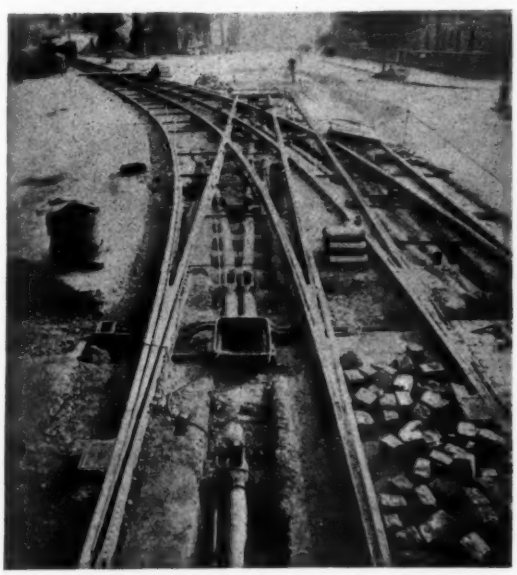
The vertical stays in a "Belpaire" firebox are often subject to severe corrosion near the inner crown. To combat this action the Great Central Railway Company are dropping short tubes over the stays, as they are inserted in the box, and filling up the small annular space between each stay and tube with Portland cement. The same method has been used by others, and it is said, with success.

After long trials of several materials, many railway companies now use boiler tubes made of copper, as were those in the "Rocket." The Midland chiefly use copper, and the London and North-Western use either copper or steel, depending on the nature of the water in the district in which an engine will work.

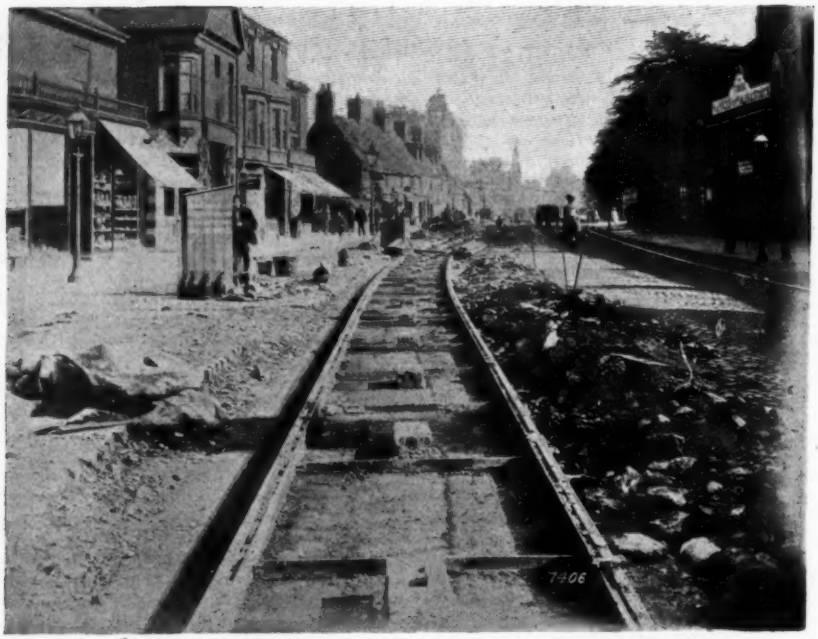
On the Midland Railway no boiler blow-off cocks are used. To empty the boiler a wash-out plug must be drawn, which cannot safely be done while the water is hot, and so the inner plates are saved from damage through being sprayed with cold water when at a high temperature.

The author states that he has found that, in some cases of compound locomotives, which were working beside corresponding simple engines, and, as far as could be ascertained, were of equal power, the ratio of (the area of h.-p. cylinder × working pressure in compound) to (the area of simple cylinder × working pressure in simple) was approximately as 100 to 80. Hence the rule for equivalent tractive effort made use of in the various tables.

Much might be said for and against compound locomotives, but there is no consensus of opinion, and probably never will be. The continually varying duty of a locomotive is so very different from that of either a marine or stationary engine that comparison fails.



"G.B." SURFACE-CONTACT SYSTEM AT LINCOLN: VIEW OF TRACK WORK, CONDUIT AND INSPECTION BOX.



"G.-B." SURFACE CONTACT SYSTEM AT LINCOLN: VIEW OF TRACK SHOWING GRANITE-BLOCKS.

## The "G.-B." Surface-Contact System at Lincoln.

THOSE of our readers who are interested in surface-contact traction will probably be already familiar with the "G.-B." system, which has now passed from the experimental stage to that of actual working. Those who would desire to become more familiar with the details of the system are referred to a special article* that appeared in the December issue of the ENGINEERING REVIEW.

Both the Lincoln Corporation and Messrs. Griffiths and Bedell are to be congratulated on the successful completion of their enterprise, which marks an important epoch in the development of British Electric Tramways. The cars have now been in regular operation for over two months; and, so far, no hitch has occurred to mar the expectations of either the inventor and contractor, or of the Lincoln authorities. A high opinion was certainly formed of both the equipment and the smoothness of running by a select number of technical journalists who were recently afforded an opportunity of inspecting the system, and we hope that other towns who object to an overhead-trolley system and wish to avoid the expensive conduit construction, may follow the example of Lincoln.

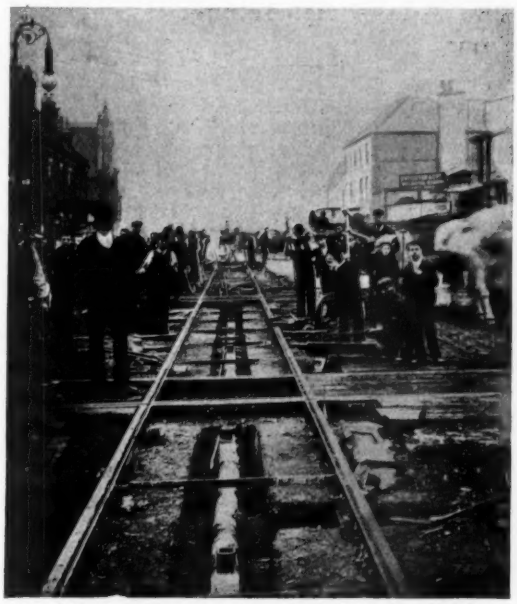
The length of route of the new tramways is $1\frac{3}{4}$ miles, of which $1\frac{1}{4}$ miles is double and half-a-mile single track. The rails, which are of British Standard Section, No. 3, weigh 100 lbs. per yard, and were supplied by the North-Eastern Steel Company, Middlesbrough.

Points and crossings are of manganese steel throughout, and were supplied by Messrs. Hadfield, of Sheffield, which firm also supplied the special work for the two railway level crossings in High Street, where the tramway crosses the double tracks of the Great Central Railway and the Great Northern Railway. Catch points supplied by Messrs. Edgar Allen & Co. are provided on each side of these level crossings and are connected up with the crossing gates. Short non-magnetic manganese steel rails are used in the loops and crossover roads in the "leads" from the points to the crossings where they come in the line of the contact studs, and were

* Surface-Contact Traction, by W. N Twelvetrees, A.M.I.E.E

supplied by Messrs. F. H. Lloyd & Co., Ltd., of Wednesbury. The tracks are paved with 4 in. by 5in. Leicestershire setts on a bed of 7 to 1 concrete.

The studs are fixed 9 ft. apart throughout, their heads measure 10 ins. by 2½ ins.; the conduit is 5 ins. in diameter, and is laid with its underside at a depth of 16 ins. below the rail level. There is a layer of concrete 5¼ ins. thick between the top of the conduit and the base of the granite setts. The diameter of the galvanised iron conductor is 1¼ ins. The service is maintained by eight cars of the double-deck type, six open and two closed on top, all by the Brush Company.



"G.-B." SURFACE-CONTACT SYSTEM AT LINCOLN: VIEW OF CONDUIT.

## Piecework Balance and Premium Calculator.

A WIDE field of application for the slide rule is found in the calculations relating to wages, piecework balances, and the "premiums" involved in the more recently introduced premium system of payment. Many attempts have been made to provide a satisfactory wages calculator of this kind, but the accuracy required has necessitated a rule of unwieldy length which is inconvenient to use. In the "Smith-Davis" calculator this difficulty has been overcome by arranging the scales on the adjacent rims of two light-running wheels carried on a convenient support.

The instrument is provided with scales, approximately 11 ft. long, having a range from 1*d.* to £20, and marked so that they can be used either for money or time calculations. The scales, divided on strips of celluloid, are affixed to the rims of two similar wheels and so arranged that the divided edges come together. The wheels are mounted on a spindle which is carried at each end in bearings, one wheel being fixed to the spindle, while the other is free to revolve upon it. The free wheel is pressed against the fixed wheel by a spring, which is sufficiently strong to cause it to turn with the fixed wheel when the latter is rotated. To facilitate the setting of the scales with respect to one another, a treadle gear is arranged to take the pressure of the spring, so that when the fixed wheel is held by the left hand, the free wheel can easily be rotated by the right hand in either direction. When the desired relative position of the two scales has been obtained, the treadle is released and the two wheels are automatically locked firmly together.

For piecework it is convenient to use the left-hand scale as the "wages scale," and the right-hand scale as the "balance scale." The purpose and method of using the instrument are best shown by an illustration, as for example:—Five men, whose combined weekly wages amount to £12 15*s.*, are engaged on a contract worth £17 12*s.* 6*d.*; the difference of these two amounts—viz., £4 17*s.* 6*d.*—is the balance which has to be divided amongst the men in amounts proportionate to their fixed wage.

To find the proportion of the balance due to each man, the operator places £4 17*s.* 6*d.* on the balance scale opposite to £12 15*s.* on the wages scale, then on the balance scale, opposite the amount of each man's weekly wage on the wages scale, will be found the proportion of the balance to which he is entitled.

For premium work it is only necessary to use a short range of the scales, and where the premium system is extensively used—although the instrument under review will serve every purpose—it is handier to use a smaller instrument with special scales.

There can be no questionas to the time and labour-saving value of the instrument, which is manufactured by Messrs. John Davis & Sons, of Derby, and we are not surprised to find that, although only recently introduced, it has already been adopted by several large manufacturing concerns.

## The Austerlitz Bridge, Paris.

THE section of the Metropolitan Railway of Paris which connects the Gare du Nord with the Place d'Italie, by way of the Magenta, Richard Lenoir and L'Hôpital boulevards, crosses the Seine on a viaduct, about 200 metres above the Austerlitz Bridge. This structure contains some new and interesting features which are fully described in an article by M. Réné Bonnin appearing in a recent issue of the *Engineering News*, New York.

The problem to be solved was to cross the Seine by means of a metallic span of 140 metres between abutments, with no point of support in the river, and with the under side of the deck at not more than 12 metres above the level of standard low water, so as to avoid too important approach bridges, and especially too steep slopes.

It was necessary, therefore, to resort to arches above the deck, and to support the latter by suspension rods fastened to the arches. It is a type of bridge similar to the one adopted in 1900, by the Western Railway Co. for crossing the Seine at Passy, on the line leading from Courcelles to the Champ de Mars,* and to those built in recent years across the Rhine by German engineers.

The engineers of the Metropolitan concluded, in their preliminary project, to adopt the type of bridge—little used as yet in Europe when it is a question of a railway bridge—shown in Fig. 1. This bridge was composed of arches having articulations at the springing lines and at the crown. Each arch was formed of two crescent-shaped lattice girders. The span at the articulations of the springing lines was 140 metres, and the rise was 28 metres, or a ratio of $\frac{1}{5}$. The deck of the bridge, of which the lowest point was 11·33 metres above standard low water, was hung from the arches by suspension rods.

Various contractors were invited to enter into a competition based on the above preliminary plan. The award was made to the Levallois-Perret Construction Society, who proposed a modification of the project, which consisted in reducing the span between the springing line articulations as shown by Fig. 2, a project which the directors adopted and which is now in process of being carried out.

As seen by Fig. 2, the span of the arch with three hinges is reduced to 107·2 metres, and the thrust of this arch is thrown, at the hinges of the springing lines, on brackets which reach, for a length of 16·4 metres, to the abutment on which they bear by means of two skewbacks fitted with adjusting keys. These skewbacks are of large area so as to distribute the pressure over the masonry as evenly as possible. In this way the height of the crescent-shaped trusses, which form each semi-arch, could be reduced and with it the weight, thus giving the whole structure the appearance of very decided lightness. The rise of the three-hinged arch is 11·726 metres, with a span of 107·2 metres. But this way of building elevated arches, with or without supporting brackets, and with a deck suspended by means of suspension bars, involves certain complications in construction which require the adoption of a few special arrangements. Among these are two of chief importance—one relating to wind pressures, the other relating to expansions and contractions arising from changes of temperature.

When a bridge is built with an arch carrying the floor, or deck, above it, the wind pressures acting on the arch and the deck are distributed over the points of support on the abutments by means of a continuous bracing which connects the different arches forming the framework of the bridge throughout their entire length. When the arches rise above the deck, this continuity of bracing cannot be kept up throughout the entire length, as a free space, necessary for the passage of trains, must be left. Thus, at the Austerlitz bridge, this bracing could only be put in over the length *MNP* (Fig. 2), the two open spaces *RM* and *PR'*, having to be left in order to let trains go by. As the result of this interruption of continuity in the bracing of the arches, the wind pressure on this part *MNP* of the arch could not be carried directly to the abutments, so that the deck of the bridge had to be used for that purpose.

To reduce the bending strains resulting from changes of temperature, and which would make it necessary to give the vertical posts connecting the deck with the arch a section out of reason, an arrangement already used by the Levallois-Perret Society for the Passy viaduct across the Seine was adopted. This arrangement consists in maintaining permanently the middle of the deck to the middle of the span *OO'*. The change in the positions of the lower ends of the vertical posts under the influence of the elongation of the deck is thus reduced to the elongation of the half-chord of the arch. To keep the middle

* *Cf.* THE ENGINEERING REVIEW, Vol. 3, p. 267.

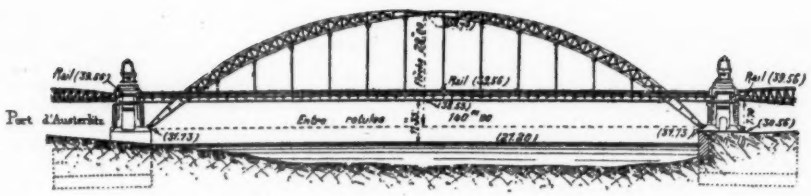



FIG. 1.—ENGINEERS' PRELIMINARY PLAN FOR AUSTERLITZ BRIDGE.

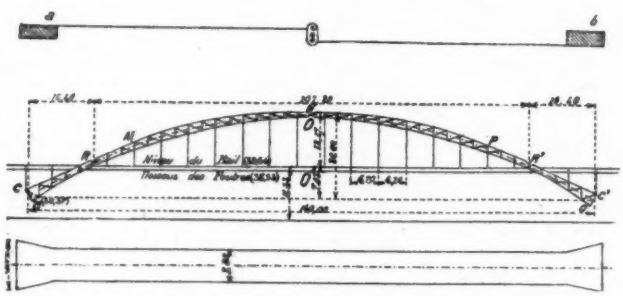



FIG. 2.—CONTRACTORS' SUBSTITUTED PLAN FOR AUSTERLITZ BRIDGE.

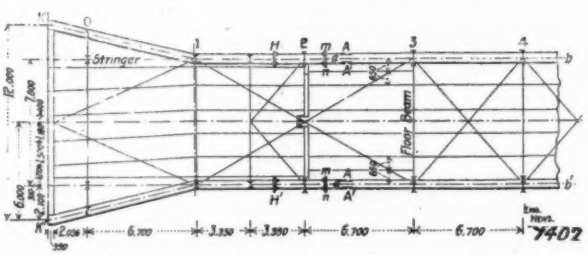



FIG. 3.—DIAGRAM PLAN OF DECK, AUSTERLITZ BRIDGE.

of the deck permanently at the centre of the span $OO'$ two tie-rods are fastened at two points, $a$ and $b$, of the skewbacks of the arches, the other ends being made fast to a balance lever of which the axis $c$ is made fast to the deck at the middle of the span.

The two arches are 7·8 metres apart between centres. Their neutral axis is a parabola of 140 metres span and 20 metres rise. These arches are composed of a central part, with three hinges of 107·20 metres span and 11·726 metres rise, supported at the springing lines by brackets which bear upon the abutments. The two half trusses of the three-hinged arch are crescent-shaped, and have latticed webs, except near joints, where the lattice work is replaced by solid plates. The outside and inside chords are shown in Fig. 4. The hinges at the springing line are similarly arranged. Fig. 5 shows the arrangement of the skewbacks on the abutments. The vertical suspension posts, 3, 4 and 5, are hinged at their points of attachment to the deck and to the arch, the remainder being fixed.

The deck which carries the rails of the track serves also to take to the abutments all the pressures due to the wind acting on the frame of the bridge. It must have, therefore, a transverse strength sufficient to stand the bending and shearing moments due to the wind.

For this purpose it has received the form of a beam laid on its side, and having the two extreme chords formed of an outside

beam, of the shape of a box girder, 0·60 metre high (Fig. 4). This outside beam passes through the feet of the posts which connect the deck with the arch, and is fastened to the deck. The outside beams are connected together by deck girders 1·50 metres high, fastened to each post and, like these, set at a distance apart of 6·70 metres between centres. Stringers 0·60 metre high, like the outside beams, connect these deck girders longitudinally and are placed under each line of rails. A floor of sheet-steel plates on top of, and a system of diagonal braces and counter braces underneath the stringers and outside beams each takes one-half of the shearing moments due to the wind. The bending moments are borne by the outside beams.

The outside beams are, as shown by Fig. 3, fastened to both the extrados and intrados of the arches and extend to the masonry abutments to which they are anchored. But, in order to prevent the outside beams from forming tie rods for the arches and causing supplementary strains in the latter, they are cut at *A*, near the intrados *m n* of the arch. They can thus slide longitudinally in the fixed parts *A m n A'*, under the influence of changes of temperature, which lengthen or shorten the deck from its middle, which is fastened to the expansion tie rods *a b* placed inside of the outside beams, the fixed ends *a* of these tie rods being attached to the immovable parts of the outside beams riveted to the intrados *m n* of the arch.

The bridge was erected by means of a service bridge across the entire width of the river, and having four openings each of 18 metres span for navigation. The metallic parts were lifted by derricks to small cars which, running on the service bridge, carried them to where they were to be used. Work was begun by erecting the supports of the arches and of the deck, the different parts of which were set by means of a traveller.

The brackets of the arches being up, and the deck with its metallic floor being completely riveted, the latter was used as a platform for raising the arches, an operation which was performed by means of a derrick on a tower, composed of four uprights, and sufficiently high for setting the topmost pieces, those at the crown. As the work on the arch advanced the sections were made to rest on the vertical suspension posts, care being taken to steady the latter by means of wooden posts and St. Andrew's crosses.

The abutments rest on a mass of masonry on a rectangular steel caisson founded by means of compressed air. The caisson was sunk evenly and without any special difficulty at the rate of about 10 ins. a day. The total cost may be estimated at £65,000.

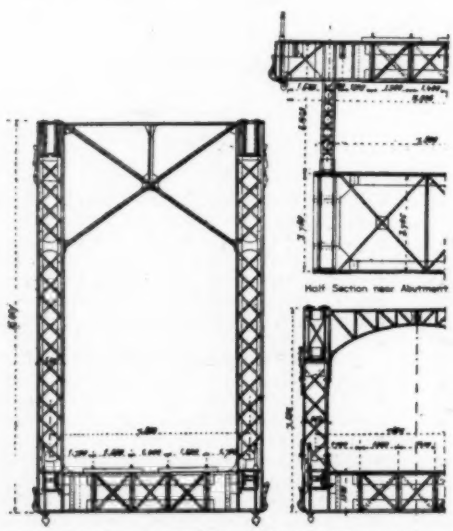



FIG. 4.—SECTIONS AT CENTRE, HALF-SECTION NEAR ABUTMENT, AND HALF INTERMEDIATE SECTIONS.

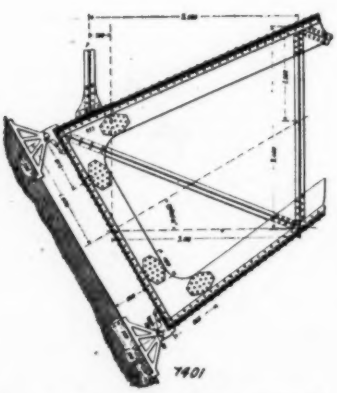
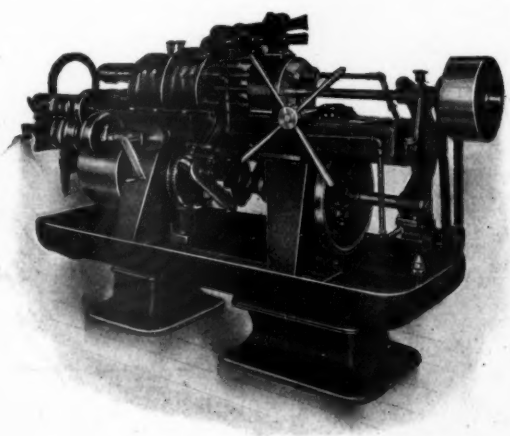



FIG. 5.—SKEWBACK BRACKET BEARING ON ABUTMENT.

## A Four-spindle Automatic Screw Machine.

We were recently afforded an opportunity of witnessing a new and ingenious four-spindle automatic screw machine, now being manufactured by the Acme Lathe and Products Co., Ltd., at their Trafford Park works, Manchester. Before the advent of the machine under review the standard form was essentially a turret lathe, with means for operating the turret and feeding the stock, each tool doing its work in turn, practically only one tool operating at a time. The "Simplex" four-spindle automatic is a radical departure from this form: instead of a turret revolving to bring the several tools successively to a single bar, four bars or rods are acted upon simultaneously by all the tools. The pan is mounted on pedestal legs, the one on the right being hollow and used as an oil reservoir, and a system of grids is used to prevent chips entering the reservoir. The feeding and chucking mechanism is mounted within the bed itself, and is actuated by cams on a drum on the cam shaft. These cams are never changed, the change of length of feed being provided for by a simple screw and slide motion. The cylinder, which carries the four spindles, is made long to give sufficient bearing for the spindles when carrying a load of bar. The method of turning the cylinder is one of the features of the machine, and is by means of a worm and wormwheel, the latter being a free wheel which is always revolving at the same speed as the cam shaft. At each full turn of the cam shaft a sliding pin, which is set in a groove on the side of the cylinder, engages itself with a slot in the free wormwheel, and the locking pin being at the same time withdrawn, the cylinder is turned one-quarter of its diameter. The sliding pin is then withdrawn positively by means of a fixed cam, and the locking bolt engages under the cylinder. The tool slide is long and rigid, and a feature is a top support provided by a spindle sliding through a bush on the top of the tool face. This spindle is firmly bolted to the cylinder casing, and forms an upper support for the tool slide. The driving mechanism is a pre-eminent feature of the machine. A single disc with turned and polished edges is mounted on the cam shaft and engages with the tool-slide. This disc can be swung on its axis to produce any "throw" or "travel" within the capacity of the machine. By means of a scale which is fixed upon the slide base, the exact travel of the tool slide can be instantly set. The spindle carrying the tap or die is revolved at a slightly higher speed than the work spindle, and this method, while prolonging the life of the die and taps in the same manner as if the spindle were stopped, also saves the great strain on the machine, and the wear of spindles consequent upon stoppage of spindle at each turn.



FOUR-SPINDLE AUTOMATIC SCREW MACHINE.

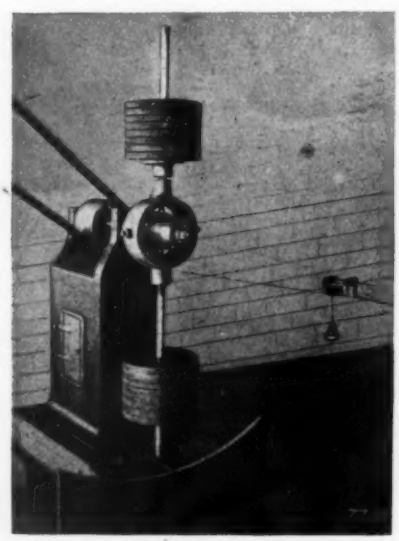
# The Friction of Roller Bearings.

An interesting series of experiments have recently been carried out with the object of determining the friction of roller bearings and plain cast-iron bearings respectively, also with white-metal bearings under similar conditions. The results obtained* are of interest as very little information on that question has been hitherto available.

Four sizes of bearings were used in the tests, measuring respectively 2, 2¼, 2½ and 3 inches diameter. The lengths of journals were about four times the diameters.

The bearings were in two parts and were held in a circular yoke by set screws. This yoke carried two vertical spindles, one above and one below, on which were placed the weights for loading the bearings. The friction was measured either by the deflection of the compound pendulum thus formed, or by weighing its tendency to deflect by means of an attached cord running over a pulley and carrying a scale pan.

* Published in *Machinery*, N. Y.



APPARATUS FOR TESTING ROLLER BEARINGS.

The shafts or journals were of ordinary machinery steel and were rotated as shown, by means of a belt and pulley.

The cast-iron bearings used for comparison were cast whole and bored to size, but the white metal ones were in halves, and were held the same as the roller bearings.

In beginning an experiment, a pointer on the lower end of the pendulum was brought to a zero mark vertically beneath the centre of the shaft by adjusting the screws in the yoke. After the shaft began to revolve the pointer was held to the zero mark by putting weights on the scale pan. The product of the force thus applied to the pendulum by the distance of the point of application from the centre of the shaft gave the moment of friction, and dividing this by the radius of journal, gave the friction at the surface of the journal. Dividing this again by the total weight on the journal gave the coefficient of friction.

In the first set of experiments "Hyatt" flexible roller bearings were compared with plain cast-iron sleeves at a uniform speed of 480 revolutions per minute, and under loads varying from 64 to 264 pounds. The cast-iron bearings were thoroughly and copiously oiled, the lubrication being rather better than would be the case in ordinary practice.

Table I., shows the results of the test on one bearing in detail, and from this it is seen that the value of $f$, the coefficient of friction, diminishes as the load increases, or in other words, the friction did not increase as fast as the load. This holds true as a general rule in all the roller bearings, but not generally in the plain bearings, either cast-iron or white metal.

TABLE I.

Journal, 2 inches in diameter. 480 revolutions per minute.

| Total load. lbs. | Friction. | | Values of $f$. | |
|---|---|---|---|---|
| | Hyatt. | Plain. | Hyatt. | Plain. |
| 64·2 | 2·34 | 10·24 | ·036 | ·160 |
| 114·2 | 3·27 | 12·10 | ·029 | ·106 |
| 164·2 | 4·21 | 19·10 | ·026 | ·116 |
| 214·2 | 4·78 | 22·35 | ·022 | ·104 |
| 264·2 | 5·15 | 26·10 | ·019 | ·099 |
| Average | — | — | ·026 | ·117 |

Table II. gives a summary of this series of experiments for the different sizes of journals, the different loads being the same as in Table I.

The relatively high value of $f$ in the 2¼ in. and 3 in. roller bearings were due to the snugness of the fit between the journal and the bearing, and show the advisability of an easy fit as in ordinary bearings.

The same "Hyatt" bearings were used in the second set of experiments, but were compared with the solid roller bearings and with plain white metal bearings freely oiled. (See Table III.) The solid roller bearings contained hardened rolls of solid steel, and guided by spherical ends fitting recesses in cage rings at each end. The cage rings were joined to each other by steel rods parallel to the rolls.

TABLE II.

Values of co-efficient of friction, $f$. Speed 480 revolutions per minute.

| Diameter of Journal. | Hyatt flexible bearing. | | | Plain bearing. | | |
|---|---|---|---|---|---|---|
| | Max. | Min. | Ave. | Max. | Min. | Ave. |
| 2 | ·036 | ·019 | ·026 | ·160 | ·099 | ·117 |
| 2¼ | ·052 | ·034 | ·040 | ·129 | ·071 | ·094 |
| 2½ | ·041 | ·025 | ·030 | ·143 | ·076 | ·104 |
| 3 | ·053 | ·049 | ·051 | ·138 | ·091 | ·104 |

Table III. shows the detailed results of experiments on one size of journal, and is similar to Table I.

The same apparatus was used as in the former tests, but heavier loads were used and the machine was run at a slightly higher speed.

There is the same indication as in Table I. of a decrease of $f$ with increase of load, and this was noticed in all the tests.

The results for the white metal are not as uniform as the others on account of the difficulty of balancing.

TABLE III.

Journal, 2 inches in diameter. Speed of 560 revolutions per minute.

| Total load. | Friction. | | | Value of $f$. | | |
|---|---|---|---|---|---|---|
| | Hyatt. | Solid roller. | Babbitt. | Hyatt. | Solid roller. | Babbitt. |
| 113·3 | 3·64 | 3·77 | 8·38 | ·032 | ·033 | ·074 |
| 162·3 | 3·77 | 4·24 | 8·97 | ·023 | ·026 | ·055 |
| 211·3 | 4·04 | 5·24 | 8·97 | ·019 | ·025 | ·042 |
| 260·3 | 4·31 | 5·37 | 8·97 | ·016 | ·021 | ·034 |
| 309·3 | 4·57 | 6·46 | 10·15 | ·015 | ·021 | ·033 |
| 358·3 | 4·71 | 6·73 | 10·75 | ·013 | ·019 | ·030 |
| 407·3 | 4·84 | 7·27 | 11·98 | ·012 | ·018 | ·029 |
| Aver. | — | — | — | ·0186 | ·023 | ·048 |

Under a load of 358·3 lbs. the solid roller bearing showed an end thrust of about 20 lbs.

Table IV. gives a summary of the tests in this series and may be compared with Table II.

Under a load of 470 lbs. the solid roller bearing developed a thrust of 11 lbs. This is due to the slight skewing of the rolls, and would vary, sometimes even reversing. The flexible roller does not develop this fault. The white metal bearing is a slight improvement over the cast-iron sleeve, but the difference is quite apt to be due to improved lubrication. (Notice the variation in the averages for the various sizes in Table IV.)

TABLE IV.

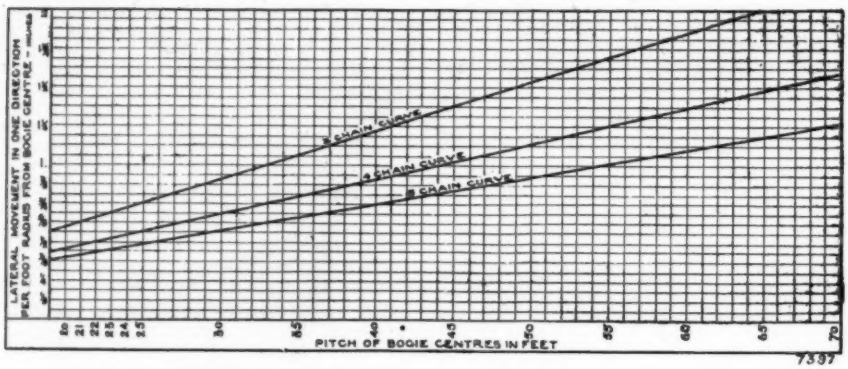
Values of co-efficient of friction, $f$. Speed, 560 revolutions per minute.

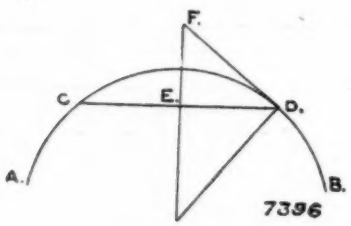
| | Hyatt flexible bearing. | | | Solid roller bearing. | | | Babbitt bearing | | |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Ave. | Max. | Min. | Ave. | Max. | Min. | Ave. |
| 2 | ·032 | 0·12 | ·018 | ·033 | 0·17 | ·022 | ·074 | ·029 | ·043 |
| 2¼ | ·019 | 0·11 | ·014 | — | — | — | ·088 | ·078 | ·082 |
| 2½ | — | — | — | ·028 | 0·15 | ·021 | ·114 | ·083 | ·096 |
| 3 | ·029 | ·022 | ·025 | ·039 | 0·19 | ·027 | ·125 | ·089 | ·107 |
| General averages | | | 3)·057 ·019 | | | 3)·0700 ·0233 | | | 4)·328 ·082 |

The difference in $f$ between the "Hyatt" flexible and the ordinary solid roller is ·0043, that is, the $f$ of the flexible roller bearing is 23 per cent. less than that of the solid roller. The difference between the roller and plain bearings is too obvious to need explanation.

In conclusion it may be said that the friction of the roller bearing is shown to be from one-fifth to one-third that of a plain bearing at moderate loads and speeds. It is also noticeable that as the load on a roller bearing increases, the coefficient of friction decreases.

In the solid roller bearing the rolls bore on a cast-iron sleeve and in the "Hyatt" on a soft steel one. If roller bearings are properly adjusted and not overloaded, a saving of from two-thirds to three-fourths of the friction may be reasonably expected, and there is no danger of the flexible rollers wearing the shaft while the solid ones showed a tendency to do so.


LATERAL MOVEMENT IN ONE DIRECTION PER FOOT RADIUS FROM BOGIE CENTRE - inches
5 CHAIN CURVE
4 CHAIN CURVE
3 CHAIN CURVE
PITCH OF BOGIE CENTRES IN FEET
7397




## The Relative Positions of Bogie to Underframe on Curves.

*By W. H. HOLDERNESS.*

RAILWAY rolling stock designers are frequently required to determine the proper clearance allowable between parts of the bogie and underframe of a vehicle when travelling around a certain minimum curve. This has often to be correctly determined, especially in the case of the steam motor coach, where the available space is somewhat limited.

The chart shows the amount of radial movement there is on a bogie standing on a 3, 4 and 5 chain curve, with different pitches of bogie centres, and thus dispenses with the somewhat tedious calculation of finding versed sines, &c.

The data for compiling this chart was obtained as follows, the figure being exaggerated for convenience.

*A C D B* is the minimum curve of radius *D O*, *C* & *D* bogie centres, *O E F* is drawn at right angles to *C D*, making *C E* = *E D* and meeting the tangent *D F* in *F*. The $\triangle$s *F E D* & *E D O* being equiangular, the side *E F* : *E D* : : *E D* : *E O*. Putting in values for *O D* & *E D*, and obtaining that for *E O* by subtracting the versed sine from the radius we get the value of *E F*. Dividing this by *E D*, we get the required amount of radial motion per foot radius.

Where there is side movement in both bogies, this must be added in addition to the above, remembering, however, that it will be only at right angles to the centre line of underframe and has no radial movement.

If there is bogie side play at one bogie only, as sometimes there is in motor coach work, a slightly larger allowance must be made, especially if the overhang is considerable.

To find this increased movement

Let $x$ = pitch of bogie centres in feet, $y$ = side play in inches and $z$ the perpendicular distance to a line at right angles to the underframe passing through bogie centre.

The side play for this point $z$ in feet.

$$\frac{x + z}{x} \times \frac{y}{12} \text{ feet.}$$

this again being added to the lateral play found on chart.

# Locomotive and Railway Notes.

*By CHAS. S. LAKE.*

**New Great Central Express Locomotives.**—In anticipation of the opening of their new route to the metropolis, the directors of the Great Central Railway placed an order some months ago for twenty-four "Atlantic" type express passenger locomotives, twelve of which were to be built at the company's works at Gorton, whilst the construction of the remaining dozen was placed out on contract with the North British Locomotive Co., Ltd, of Glasgow. Of the twelve engines to be built at Gorton, two were to be three-cylinder compounds and the others of the ordinary two-cylinder "simple" type. An illustration of one of the engines built by the North British Locomotive Co. is shown herewith, as are drawings of the new compounds, details of which will appear next month.

In all more important respects the new locomotives are identical with those of the same type already in service on the Great Central Railway. The diameter of the cylinders has, however, been increased from 19 in. to 19½ in., and 21·3 sq. ft. of additional heating surface has been provided in the boiler and fire-box, the total being now 1,931·3 sq. ft., as against 1,911 sq. ft. of the previous engines.

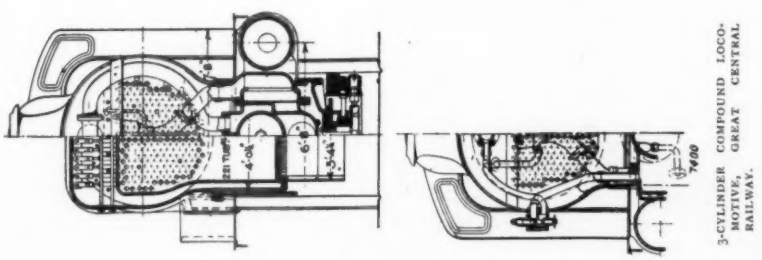
The cylinders, as before said, are 19½ in. diameter, and they have a stroke of 26 in. The coupled wheels, which have a diameter on tread of 6 ft. 9 in., are arranged on a wheelbase of 7 ft. 3 in., the total engine wheelbase being 27 ft. 9½ in. The boiler has a "Belpaire" fire-box, and upon this are mounted four safety valves, set to blow off at 200 lbs. per sq. in., this being 20 lb. per sq. in. more than in the earlier engines. The boiler contains 221 tubes of 2 in. diameter outside; these provide 1,777·9 sq. ft. out of the total heating surface of 1,931·3 sq. ft. The tender runs upon six wheels 4 ft. 3 in. diameter, and carries 4,000 gallons of water and 6½ tons of coal. It is fitted with water pick-up apparatus, operated by means of a combined screw and steam cylinder arrangement.

It is interesting to compare this design with that of Mr. Ivatt on the Great Northern Railway. The Great Central engines have much larger cylinders but a considerably smaller total heating surface than their contemporaries on the Great Northern. The figures are as follows:—

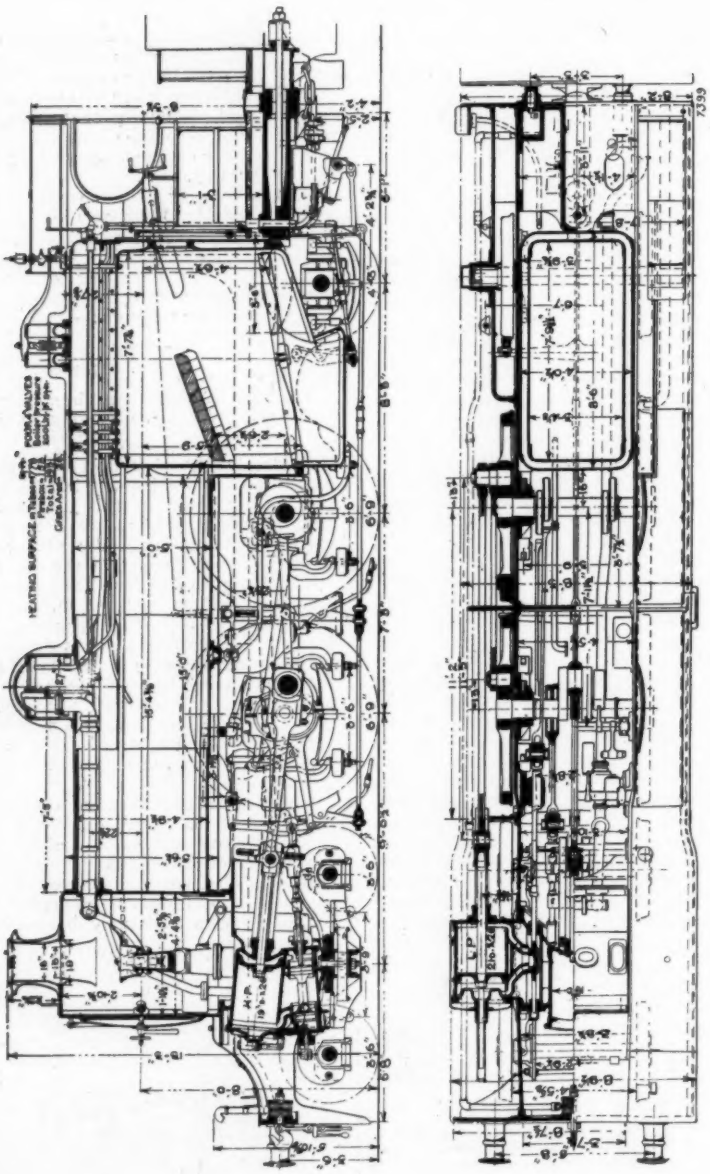
| | Cylinders. | Total heating surface. |
|---|---|---|
| Great Central engine | 19½ by 26 in. | 1,931·3 |
| Great Northern engine | 18¾ by 24 in. | 2,500 |

Evidently Mr. Robinson finds that his boilers are fully adequate in steam generating power, for in this new series he has, as before said, increased the cylinder capacity without materially adding to the total heating surface. On the other hand, the boiler pressure has been raised and stands at 25 lbs. per sq. in. more than that of the Great Northern engines, and the load on the coupled axles is greater by a ton than in the case of Mr. Ivatt's "No. 251" class of locomotives, so that the additional force exerted through the medium of the larger pistons may be used to greater advantage, and there is hardly any likelihood of the engines ever running short of steam.

These comparisons serve a useful purpose, as showing the difference in the methods of two of the most eminent British locomotive engineers, each responsible for providing adequate engine-power for working a fast and heavy passenger traffic. Whatever view one may be inclined to



3-CYLINDER COMPOUND LOCOMOTIVE, GREAT CENTRAL RAILWAY.



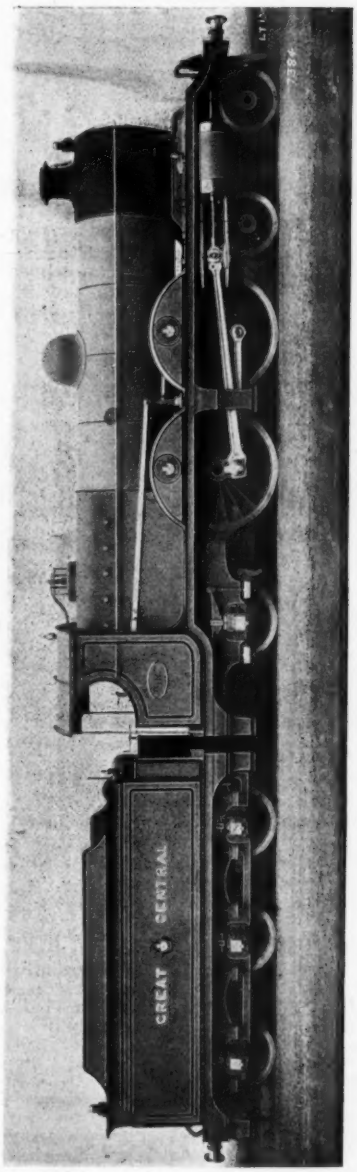
3-CYLINDER COMPOUND EXPRESS LOCOMOTIVE, GREAT CENTRAL RAILWAY.

take as to the relative merits of the two designs, it is quite certain that both are proving wonderfully efficient in the performance of the duty they were designed for.

**Locomotive with Thermal Storage Tank, Lancashire and Yorkshire Railway.**—The writer has been favoured by Mr. Geo. Hughes, M.Inst.C.E., Chief Mechanical Engineer of the Lancashire and Yorkshire Railway, with a photograph and particulars of engine No. 632, a 2-4-2 type radial tank locomotive, used for suburban service on that line, which has been fitted with Mr. Druitt Halpin's system of thermal storage, consisting of a cylindrical water tank placed above the boiler, and connected thereto by means of a pipe. The method of operation with this system of feeding locomotive boilers has already been described in THE ENGINEERING REVIEW, but it will not be out of place, perhaps, to briefly restate these in connection with the present application of the system. All the feed water, which is maintained at or about the same temperature as the water in the boiler, is passed through the cylindrical tank, the water being heated by steam generated during the intermittent periods, when the engine is standing, or the safety valves are blowing.

The water, thus heated, is fed to the boiler as required, when the engine is running. the supply being regulated by means of a valve in the driver's cab. The tank is filled by injectors in the usual way, and it can be filled nearly to the top without danger of overflowing; a water gauge on the end showing the height of the water in the tank. Tests made with stationary engine installations, fitted up with this apparatus, have demonstrated its superiority over the ordinary methods employed for feeding boilers, and there would appear to be no reason why the same results—showing an increased evaporating efficiency and fuel economy—should not be forthcoming in the case of locomotives. The Lancashire and Yorkshire Railway engine, illustrated, has the following principal dimensions:—

| | | | |
|---|---|---|---|
| Cylinders, dia.... ... ... ... | | | 17½ in. |
| ,, stroke ... ... ... | | | 26 in. |
| Wheels, dia. (radial) ... ... ... | | 3 ft. | 7¾ in. |
| ,, ,, (coupled) ... ... | | 5 ft. | 8 in. |
| Wheelbase, ,, .. ... ... | | 8 ft. | 7 in. |
| ,, (total) ... ... ... | | 24 ft. | 4 in. |
| | T. | C. | Q. |
| Weights (loaded), front radial wheels ... | 12 | 16 | 0 |
| ,, ,, driving wheels ... ... | 18 | 19 | 0 |
| ,, ,, trailing coup. wheels ... | 17 | 18 | 0 |
| ,, ,, hind radial ,, ... | 10 | 14 | 0 |
| Total ... | 60 | 7 | 0 |




"ATLANTIC" TYPE EXPRESS "SIMPLE" LOCOMOTIVE, GREAT CENTRAL RAILWAY.

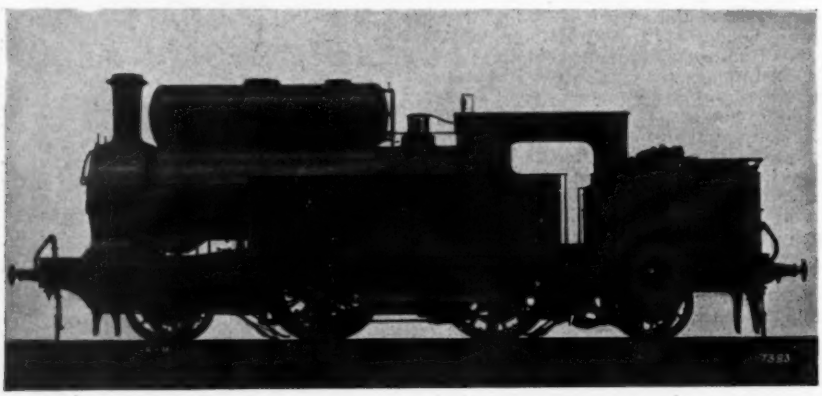
| | | | |
|---|---|---|---|
| Boiler diameter | ... | ... | ... 4 ft. 2 in. |
| Length between tube plates | | | ... 11 ft. 0 in. |
| | shell. | | copper box. |
| Firebox length | ... 6 ft. 0 in. | | ... 5 ft. 4¾ in. |
| ,, width | ... 4 ft. 1 in. | | ... 3 ft. 6 in. |
| ,, height | — | | ... 5 ft. 0¾ in. |
| Tubes, No. 220 | | | |
| ,, dia. (outside) | ... | .. | 1¾ in. |
| Heating surface (tubes) | ... | ... | 1,108.73 sq. ft. |
| ,, ,, (firebox) | ... | . | 107.68 sq. ft. |
| ,, ,, (total) | . | ... | 1,216.41 sq. ft. |
| Grate area | ... ... | ... | 18.75 sq. ft. |
| Capacity of tank | ... ... | ... | 1,340 gallons. |
| Capacity of storage tank at working level | ... | ... | 375 gallons. |
| Fuel capacity | ... | ... | 2 tons. |

**An American Locomotive Engineer on Superheating of Steam.**—Mr. J. E. Muhlfeld, General Superintendent of Motive Power of the Baltimore and Ohio Railway, and one of the best-known locomotive men in the United States, in the course of a paper which he read at the Washington meeting of the International Railway Congress, held last year, stated that:

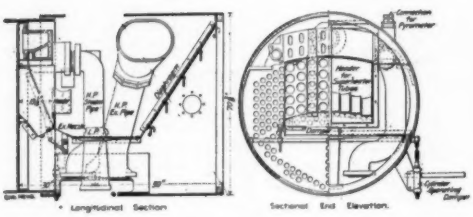
"The economy shown by superheating is so well defined, that there is now no question of its effective and substantial saving. Superheated steam locomotives, whether compound or simple, show about the same percentage of economy over an ordinary simple locomotive. A number of tests have been made with simple types of locomotives, using superheated steam, in comparison with similar types of compounds, but as yet no definite conclusions (more particularly with respect to the successive superheating before the steam enters the cylinders of compound locomotives) have been arrived at. It is estimated that the use of superheated steam in connection with compound engines, will give about the same results by reduced loss in cylinder condensation, as the triple expansion of steam without the superheating.

"The fact that the compound can be replaced by the simple locomotive, with increase of power and lower pressure in the boiler, is an advantage, even if no economy in fuel is obtained. As superheated steam applied to locomotives gives a higher thermo-dynamic efficiency than that realised from compound locomotives using saturated steam, it will enable the possibility of obtaining the advantages of compounding without the introduction of the objectionable features. The possibility of increasing the capacity and economy of present locomotives, by superheating, is of even greater importance, as boilers which may be deficient in design or capacity, can be much improved in effectiveness, and superheaters can be applied without altering the general design or construction of the boiler or mechanism.

"In order to profit by the increased power resulting from superheating, the size of the cylinder should be increased to an extent proportional to the amount by which the consumption of heat by the ordinary locomotive exceeds that of the locomotive using superheated steam, when both do the same amount of work. Also, on account of the volume of superheated steam being greater than an equal weight of saturated steam for equal work, a longer cut-off may result from expansion below the point of saturation, and some of the advantages of superheating will be lost. Therefore, on new locomotives, fitted with superheaters, it would seem advisable to slightly increase the cylinder volume to insure the greatest benefit."



LOCOMOTIVE WITH THERMAL STORAGE TANK, LANCASHIRE AND YORKSHIRE RAILWAY.



SMOKEBOX AND SUPERHEATER.

Apropos of the foregoing, a large consolidation (2-8-0) type freight locomotive, built at the Schenectady Works of the American Locomotive Company, has been fitted experimentally with a "Cole" superheater. This apparatus is illustrated in the accompanying drawings, for which, as well as the particulars relating to it, the writer is indebted to the *Engineering News*, of New York.

The illustrations show the arrangement of the superheater tubes. The boiler has tubes 15 ft. 9 in. long, and forty of these are 3½ in. diameter. In each of these large tubes (and close to the upper side of the tube), is placed a 2-in. tube closed at the fire-box end, and extending beyond the smoke-box tube plate to the rear compartment of a header or chamber in the smoke-box, and 13¼ in. from the tube plate. Inside of each 2-in. tube is a 1·3 in. tube, open at the rear or fire-box end, and extending through the partition of the header into its front compartment. The flame and gases pass through the largest tube. The saturated steam from the boiler enters the front compartments of the header, and passes back through the small tube, returning through the 2-in. tube to the rear compartment of the header, whence it passes to the high-pressure cylinder.

The locomotive is a two-cylinder compound, with high-pressure cylinder 23 in. by 24 in., and low-pressure cylinder 35 in. by 34 in. The coupled wheels are 5 ft. 3 in. diameter, and are arranged on a base of 17 ft., the total wheel-base of the engine being 25 ft. 7⅜ in. diameter at the front end, and containing 264 iron tubes, of which 224 are 2 in. diameter, and the remaining (superheater) tubes, 3½ in. diameter, the length over tube plates is 15 ft. 9 in. The total heating surface is 2,565·5 sq. ft.; super-heating surface, 261·0 sq. ft.; grate area, 46·8 sq. ft., and working steam pressure, 210 lbs. per square inch. The smoke-box contains a spark-arresting device, consisting of a diaphragm and netting. The total tractive force of this engine, calculated at 85 per cent. of the boiler pressure, amounts to 37·300 lbs.

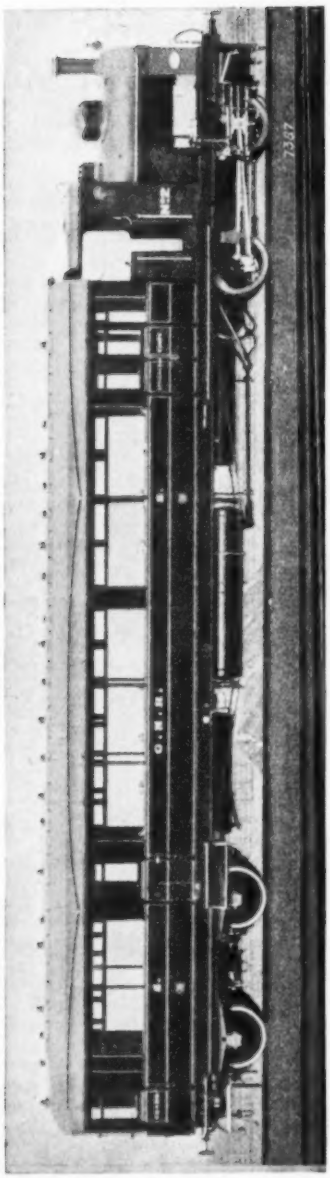
**Steam Rail Motor Cars : Great Northern Railway.**—The writer is indebted to Mr. H. A. Ivatt, M.Inst.C.E., Chief Locomotive Engineer of the Great Northern Railway, for the accompanying photograph and particulars of one of the steam motor coaches designed by him and built at Doncaster Works for service on the Louth and Grimsby section of the line. In these cars, which are the first propelled by steam to be used on the Great Northern Railway, the engine takes the form of a small outside cylinder locomotive mounted on a four-wheeled bogie and arranged so as to be detachable from the carriage portion, which is supported at the rear end by a standard Great Northern Railway pattern carriage bogie. The car body is divided into several compartments, including luggage compartment, third-class smoking and non-smoking accommodation, a first-class saloon and guard's compartment. The controlling mechanism is duplicated and so arranged that the car can be operated either from the engine cab or from the guard's compartment at the rear of the vehicle, according to the direction of travelling.

The leading dimensions are as follows :—

| | |
|---|---|
| Cylinders ... ... ... | 10 in. dia. by 16 in. stroke. |
| Wheels ... ... ... ... | 3 ft. 8 in. dia |
| Heating surface ... ... | 382 sq. ft. |
| Grate area ... ... ... | 9½ sq. ft. |
| Working steam pressure ... | 175 lbs. per sq. in. |
| Car body ... ... ... | 49 ft. long. |
| Seating capacity ... ... | 53 passengers. |

The distance from Louth to Grimsby is fourteen miles, and, in addition to the four intermediate stations on the length, six new "haltes" have been erected for service by the new rail motors. These are located at Fotherby, Utterby, Grainsby, Holton Village, Weelsby Road and Hainton Street, and in addition to the passenger traffic dealt with at these haltes, parcels will be accepted at a uniform charge of 4*d*. per package for conveyance to any station between Louth and Grimsby.

**Another Locomotive Development on the Great Western Railway.**—Those who follow the subject of locomotive engineering in this country will agree that in the matter of developing the use of locomotive types the Great Western stands ahead of all other British railways. On the

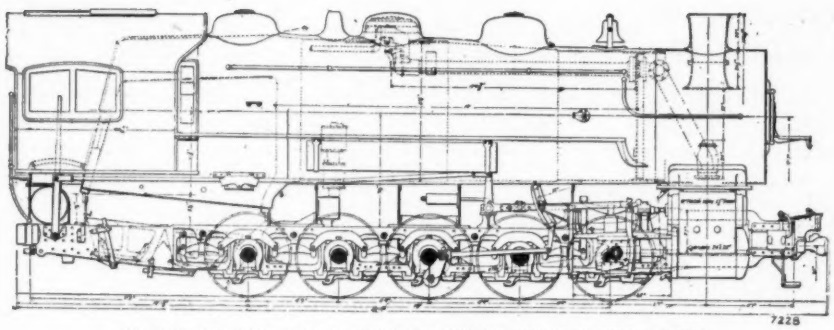


STEAM RAIL MOTOR CAR, GREAT NORTHERN RAILWAY

line in question practically all of the most advanced types of engine are employed both for passenger and goods traffic. The wheel arrangements include 4-4-0, 4-4-2, 4-6-0, and 2-6-2, besides others, in passenger service, and 2-6-0, 4-6-0, and 2-8-0 in connection with goods train working, the only notable absentee from the latter category being, strangely enough, the 0-8-0 type of engine so popular on most of the remaining "heavy" lines. Having given the four-cylinder compound (4-4-2) type locomotive a thorough trial on fast and heavy passenger work, Mr. G. J. Churchward is now about to test the capabilities of a four-cylinder "simple" engine with the same wheel arrangement. The new locomotive at present nearing completion at Swindon Works has been designed on the most generous lines for power development, and at the same time it will be able to run freely.

**Heavy Shunting Locomotive : New York Central Lines.** — The American Locomotive Company have recently delivered to the Lake Shore and Michigan Southern Railway, from their Brooks Works, some exceptionally large and powerful shunting or "switching" locomotives for special service in hauling trains over the "humps" or summits in gravity distributing yards. The engines are of exceptional size for their type, even in American practice, and are equal in nearly every respect to the heaviest freight locomotives used on the main lines for hauling trains of from 3,000 tons and upwards behind the tender.

As will be seen from the drawings, there are five pairs of coupled wheels, the middle pair of which are driven direct by outside cylinders, and the slide valves, which work above the cylinders, are actuated by the Walschaerts' gear. The boiler, which is of large proportions, is built up in three rings, the intermediate one being tapered. The diameter next the smoke-box is 6 ft. $8\frac{1}{16}$ in., and at the throat-plate 7 ft. $3\frac{1}{2}$ in. ; there are 447 tubes 2 in. in diameter and 19 ft. in length. These provide 4,422 sq. ft. of heating surface, to which is added 203 sq. ft. contributed by the firebox, bringing the total up to 4,625·4 sq. ft ; the grate area is 55 sq. ft., and the working steam pressure 210 lbs. per sq. in. Unusually large cylinders are employed, viz., 24 in. dia. by 28 in. stroke, and the coupled wheels, all of which have flanges in this design, have a diameter on tread of 4 ft. 4 in. They are grouped closely together, the wheelbase being only 19 ft. In working order the engine,



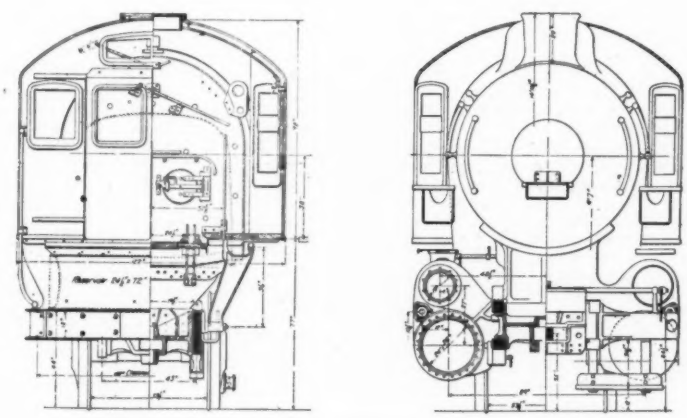
GENERAL ELEVATION, HEAVY SWITCHING LOCOMOTIVE, NEW YORK CENTRAL LINES.

without tender, weighs 120 tons 10 cwt., all of which is, of course, available for adhesion. The tractive power is 55 300 lb., and the following ratios apply to the design, viz:

| | |
|---|---|
| Tractive weight ÷ tractive effort ... ... ... | 4·8 |
| Heating surface ÷ grate area ... ... ... | 84 |
| Tractive effort × diam. driving wheels ÷ heating surface ... ... ... ... ... ... | 622 |
| Total weight ÷ tractive effort ... ... ... | 4·8 |

The frames are of extremely heavy section, being 6 in. in width by 7 in. deep over the driving boxes. Strong cross bracing is used at several points by means of steel castings, and there are four supporting plates from the boiler between the cylinders and the throat-plate.

Two of the engines are employed in the hump yard at Elkhart, two at Collinwood, and a further one on banking service for the west-bound trains out of Cleveland. The grades in the hump yards are from 0·67 per cent. to 2·00 per cent., and the Cleveland grade is at 39 ft. per mile. The engines have been designed to handle in the hump yards the heaviest trains which can be hauled there by one of the regular main line locomotives.



HALF-SECTIONS, HEAVY SWITCHING LOCOMOTIVE, NEW YORK CENTRAL LINES.

# Automobile Engineering Notes.

*By ROBERT E. PHILLIPS, M.I.Mech.E., A.M.Inst.C.E.*

Now that the Paris Salon de l'Automobile is over, one is in a position to accurately gauge the trend of design in cars of foreign manufacture, for although the products of the majority of the best-known French manufacturers were exhibited at Olympia, there is no gainsaying the fact that such exhibits did not in any way represent the French automobile industry. For every one of the French "Marks," so well-known in this country, there are at least ten that are more or less unknown, the majority of which are each year becoming more on a par with the classic marks.

One cannot deal with an exhibition such as the Salon de l'Automobile of 1905 without commenting on the gorgeousness of its *tout ensemble*; neither can one view such an exhibition without reflecting on the *raison d'être* of its sumptuous surroundings. It cannot be supposed for a moment that those interested in automobilism are drawn to an exhibition of motor cars because of its decorations and illuminations, and one can only assume that the promoters of the Salon de l'Automobile have in view "gate money" when they lay themselves out to influence attendance by the glamour of decoration. Anyone who has spent several days in the Exhibition can only come to the conclusion that a very large proportion of the visitors are not drawn there by the exhibits. A large number are undoubtedly influenced by the "Tombola," others go because it is the proper thing to do, and many go merely out of curiosity. The question therefore arises as to the benefit to the trade of these enormous numbers of visitors. There is one thing quite certain, and that is that the large attendance conduced greatly to the discomfort of those who were there on business intent.

One hears comparisons made between the Paris Show and the Olympia Show. There can be no comparison. The automobile industry in France is as far ahead of the industry in this country as the industry in this country at the present time is ahead of what it was five years ago, if not more so. The striking feature of the industry in France is not so much the large number of makers of cars as the enormous number of firms engaged in the production of component parts, and we are of opinion that the industry in this country will never succeed in catching up with the industry in France until the manufacture of component parts is more seriously taken up over here. A large proportion of the manufacturers of motor cars in France started building cars with component parts of recognised firms, and even at the present day many of the best-known cars contain component parts of "exterior" manufacture. It is an object lesson to see the exhibits of such firms as Lemoine, Arbel, Compagnie des Forges et Acieries de la Marine et D'Homécourt, Grouvelle et Arquembourg, La Société Industrielle des Télephones, Malicet and Blin, and others, including as they do types of their component parts as supplied to some of the best and largest automobile manufacturers in France.

The British manufacturers are apt to look upon themselves as the most serious competitors of the French in the automobile markets of the world, but those who have taken note of the wonderfully rapid strides of the industry in Italy cannot shut their eyes to the fact that the race lies with the Italians rather than with us. There were no less than eight Italian firms exhibiting at the Salon, and, with a single exception, all showed cars which would bear comparison with cars exhibited by any other nation. We believe that the rapid advance of Italian firms can be attributed to the fact that when entering into automobile construction they were not too proud to copy in the first instance and improve afterwards. What an enormous amount of capital would have been saved in this country had our pioneers followed the same line.

With a single exception the exhibits of British manufacturers compared most favourably with those of the cream of the French industry. That the one firm we refer to is a young one in the industry is no excuse either for the dirty state of its exhibits or the blatant verbosity of the attendant in charge.

A combination which may have a far reaching effect is seen in the Dolores Company which is formed and financed by Americans and builds cars to French design by French workmen. We shall watch the future of this company with interest.

Taken as a whole the trend of design as disclosed by the Salon differs very little from that disclosed by the Olympia Show. The most important difference is the non-adoption of the six-cylinder engine. Even the Panhard firm, who had two six-cylinder cars exhibited at Olympia did not show one in Paris. The horizontal engine, at all events for pleasure vehicles, appears to be a thing of the past. There is a general tendency to place the gear box as far to the rear of the chassis as possible, which both shortens the length of the driving chains and keeps the sprocket wheels on the differential axle out of the way of the side entrance doors. A great improvement is noticeable in the construction and arrangement of the radius rods. These are in many cases now of plate or girder type instead of being merely rods or bars, and in some cases their attachment to the frame is by means of a universal joint. It is interesting to note that the variable inlet valve so long employed in the Renault engine has been abandoned in favour

of an improved throttle, thus bearing out the opinion we expressed in our last notes.

Messrs. Richard-Brazier have made a departure in engine practice that has much to commend it. The ignition cam shaft is placed alongside the cylinder heads so that the cams operate the ignition tappets direct without the intervention of rods. One of the cars of this firm was fitted with a second gear box between the main gear box and the rear axle, the second gear being arranged to give either a direct through drive or a drive with a reduction of about 60 per cent., the change being effected by means of a supplemental lever. For touring cars this appears to be a desirable appliance as it enables the ratio of the main gearing to be varied according to the nature of the country to be traversed.

Although there are a larger number of firms employing metal-to-metal clutches the old leather-faced cone clutch is still the most popular. In the new 40 h.-p. touring "Richard Brazier" the device used on the car that won the Gordon-Bennett cup has been adopted. It consists of four sliding bolts carried by one part of the coned clutch which engage four holes in the other part of the clutch when the clutch pedal is completely released, thereby positively locking the two parts together and so entirely preventing slip.

Compared with previous exhibitions, there were quite a large number of small cars or voiturettes, but with few exceptions they were much inferior to the vehicles of this type produced in this country. One car, however—the Sizaire-Naudin—was constructed on most original lines, the object being to reduce the cost of production without impairing the utility of the vehicle. The frame consists of two wooden side members bent inwardly at the front end to increase the lock of the steering wheels. These two members are not connected at their rear ends but are connected at their front ends to a metallic cross member which carries vertical sockets in which the pivots carrying the steering wheels both slide and turn, the upper ends of said pivots being supported by a transverse elliptical spring carried by the cross member. The rear suspension consists of two half-elliptical springs fixed to the side members of the frame at about the centre of their lengths, the free ends of the said springs being attached to the casing of the rear live driving axle. The water tank forms the dashboard, and the fuel tank is placed immediately behind the radiator which is of the vertical type with top and bottom water chambers. The coil and accumulators are carried at the sides of the fuel tank so that the wiring for the electric ignition is reduced to a minimum. The engine which is a single cylinder one developing 7 h.-p. calls for no special reference.

The most striking departure from existing practice was disclosed in the chassis exhibited by Cornilleau and St. Beuve. The four cylinders of the engine are in one casting which is of approximately rectangular form, having chambers in each side through which the rods for the valves and the low tension ignition pass, all of which are readily exposed by the removal of easily detachable cover plates. The tappets for the low tension ignition work in the horizontal plane around the heads of the inlet valves, the plugs with which they contact being adjustable in the valve chambers to compensate for wear. By removing the caps closing the holes in the valve chambers both the working of the valves and of the tappets of the ignition can be seen. Both the inlet and the exhaust valves have variable lifts, the object apparently being to control the running of the engine by throttling the exhaust and at the same time to employ mechanically operated inlet valves. It is obvious that mechanically operated inlet valves cannot be employed in an engine in which the exhaust valves have a variable lift, and for this reason such a method of control has only been employed in engines fitted with atmospherically operated inlet valves. By the use of the automechanical inlet valve referred to in our last issue the necessity for varying the lift of the inlet valves with this type of control would disappear and much complication be thereby avoided. The fan behind the radiator is completely surrounded by a sheathing forming an extension of the frame of the radiator so that the air induced is drawn through all the orifices in the radiator. The live axle is fitted with a spring drive and the road wheels are mounted on the tubular case of the axle and receive their drive at the outer ends of their hubs, so that the driving axle bears none of the weight. The sliding pinions of the change speed gear are loose on the shaft until they become partly meshed with the fixed pinions, after which dog clutches on said pinions engage similar clutches on the shaft. A device for starting the engine from the seat is fitted which consists of a pedal —which is also the clutch pedal—the depression of which operates to rotate the crank shaft through bevel gearing which automatically releases itself when the engine starts. We shall hope to deal with the engine of this chassis at greater length when we are able to give illustrations of it. We understand that the English rights in this car have been acquired by a firm in this country who have the reputation of knowing a good thing when they see it, and we congratulate them on their acquisition.

La Société des Automobiles Philan exhibited in addition to the car shown at Olympia, a 40-60 h.-p. car which has a direct drive on all three speeds. There is no gear box in the accepted sense of the term, but the live back axle is fitted with three bevel wheels all of which are loose, but each is capable of being independently fixed to the axle. With these three bevel wheels three bevel pinions mounted on the rear end of the propeller shaft gear give the three forward speeds, the wheels for the time being not locked to the driving axle running free.

A large number of firms exhibited cars fitted with self-starting devices, the majority of

which were entered for the trial organised by the Automobile Club of France for prizes offered by M.M. Deutch. This competition resulted in the first prize being divided between the firm of Mors and Mons. Isnard, the third prize being awarded to Mons. Lemale. The Mors device consists of a hand air-pump conveniently placed to be operated by the driver. This forces air through a small surface carburettor, thence into the cylinders of the engine through small cocks which are opened at the same time as the relief cocks in the cylinders are opened by a lever on the dashboard so that the carburetted air entering the cylinders first displaces their contents which escape through the relief cocks. The respective cocks are then closed, and the advance ignition lever moved through its arc when one of the charged cylinders fires and sets the engine in motion.

The Isnard device consists of a small cylinder the piston of which acts on the crank shaft of the engine by a rack and pinion device. At one end of the cylinder is a valve opened by a lever, which on being operated brings the rack and pinion into gear, a charge of carbonic acid gas being at the same time admitted from a reservoir into the cylinder, which expanding drives the piston forward and rotates the crank shaft of the engine. Immediately the engine starts the cylinder rises clear and the piston is brought back to its normal position by a spring.

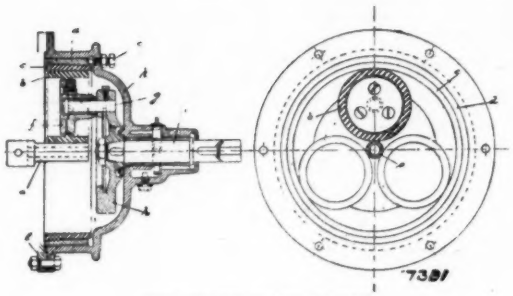
The Lamale device consists of a coil spring which is wound up by the engine itself, and is automatically disconnected when fully wound. The barrel in which the spring is coiled is connected by means of gearing with the crank shaft of the engine so that when the spring is released by the driver from his seat, sufficient motion is imparted to the engine to enable it to perform its own functions.

In the heavy vehicle section one could not help being struck with the large number of chassis suitable for commercial purposes exhibited and the all-round excellence both in design and workmanship. The most disappointing exhibit in this section was the heavy chassis of one of the oldest and best-known manufacturers in France. Here at all events is a production on which racing does not seem to have had a beneficial effect. The most noticeable feature in these chassis for commercial vehicles is the placing of the footboard over the engine, which not only gives increased platform area, but also places the driver in a higher position where he can get a better view of the road. Amongst the commercial vehicles were several fitted with six wheels. Although this is not novel, its introduction on an extended scale for commercial vehicles will probably be a thing of the near future if, as is alleged, it is a preventive of skidding.

# Abstracts from the Foreign Press.

**Hydro-Electric Plant at Mezieres.**—To provide additional power for an engineering works, a new hydro-electric plant has, says *Le Génie Civil*, just been installed at Mézières, in which the difference of level at the neck of a horse-shoe bend of the Meuse is utilised, the water being drawn off through an old mill-race. The normal fall is 10 ft., and the volume of water available is between 4,000 and 4,500 gallons per second. This drives three "Fontaine" turbines of 187 h.-p. each; but owing to the fluctuations in the river, the whole of them can only be run during the winter season. The vertical turbine shafts actuate the driving pulleys through bevel-gear, giving a pulley speed of 180 revolutions. Owing to the confined space, the driving belts are passed under instead of round the dynamo pulleys and round a "Lenix" bobbin, thus preventing slipping and reducing loss of power to a minimum. The regulating valves of the turbines are controlled by "Ribourt" governors; and since the river authorities insist on a uniform consumption of water, whether the turbines are running or not, a draw-off valve is connected with the valve of each turbine by a balance beam, so that the effective apertures of the two are maintained in inverse proportion. When the river is low, however, the draw-off valves can be closed by lowering the points of suspension of the beams by means of threaded suspension rods. In addition to this, each valve can be worked by hand, the valve rod being mounted, for this purpose, on a fork traversed by the head of the beam and easily disconnected from the latter. The Westinghouse three-phase dynamos furnish current at a tension of 2,200 volts and run at 600 revolutions, which current is conveyed to the works, 1,000 yards away, through underground conduits, and is there transformed into 115-volt continuous current for driving the machinery.

**Ferro-Concrete Water Tower at Florence.**—A ferro-concrete water tower, with a reservoir holding 22,000 gallons, has been erected at the S. Salvi Asylum, Florence, to the designs of Professor A. Muggia, of Bologna. The following particulars are taken from the December number of *Beton und Eisen*:—The foundation, which is 15 ft. below the surface, consists of a layer of ferro-concrete, 8 in. thick, and is hexagonal in form, within a circle of 20½ ft. diameter. From this rise six hexagonal pillars, 3 ft. thick, connected at the base by stays, 8 in. wide and 10 in. high, and at the top by architraves, 3 ft. wide and 8 in. high. The central space is filled with ordinary ballast concrete, topped with earth. The height of the tower to the bottom ring of the reservoir is 55 ft. 9 in., divided into four



COUPLING FOR ELECTROMOTORS.

open zones. In the lowest zone, which is 19½ ft. high, the pillars are tapered and converging, and the three upper zones are 12 ft. in height. The reservoir is supported on six brackets, resting on the bottom ring and carrying vertical 6 × 10-in. ribs. The outer cylinder is 20 ft. high, 3⅛ in. thick and has an internal diameter of 15 ft., and the feed and discharge pipes, and ladder are contained in an inner cylinder, 32 in. wide. A vertical wall divides the reservoir into two chambers, which are connected at the bottom, but can be shut off for repairs, &c. In calculating the dimensions, a wind pressure of 20½ lb. per square foot on the reservoir was taken as the basis, the maximum tension on the ironwork (½-in. vertical rods and bars) being assumed as 14,000 lb. per square inch, and on the concrete as 426 lb.

**Polyphase Motor Combination with Variable Speed.**—To enable the fan at the Nothberg Colliery, Eschweiler, to run at variable speeds from 300 to 375 revolutions per minute, according to the requirements of the mine, the following combination of motors, described in a recent issue of *Glückauf*, has been installed by the Felten and Guilleaume-Lahmeyerwerken Co. For the maximum speed, two 80 h.-p. polyphase induction motors are coupled on opposite ends of the fan shaft, whilst, for the lower speed, one of these motors is connected with a 16 h.-p. synchronous motor. This latter is built on the lines of a continuous current motor, and is fitted with three slip-rings connected with the armature coils, which rings receive current from the secondary armature of the induction motor. The number of poles of the synchronous motor depends on the condition that the speed must be equal to the slip of the induction motor at the desired speed; and as the induction motor runs at 375 revolutions with a periodicity of 50, the secondary periodicity at 300 revolutions will be 20, and the number of poles consequently 4. Hence, if the asynchronous motor runs with a slip corresponding to 300 revolutions, the electric energy corresponding to this slip will be returned by the synchronous motor (also making 300 revolutions) to the fan shaft, so that no loss is incurred in resistance, and a high efficiency is obtained. At the same time the lag between current and tension, accompanying the use of a single asynchronous motor, is compensated, so that the cost is nearly equal to unity, and back pressure being eliminated, a further increase in working efficiency is obtained.

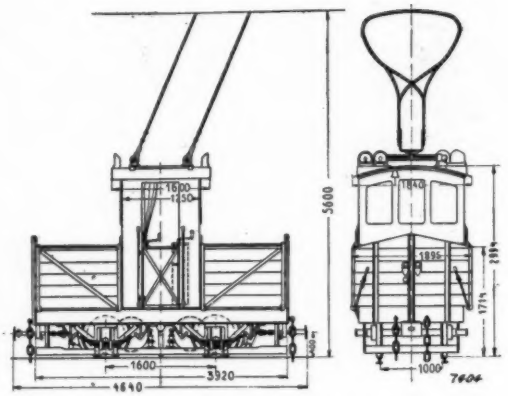
**A Coupling for Electromotors.***—A polished steel extension, *a*, is attached to the end of the armature shaft, and engages with 3-4 rings, *b*, of hard, polished Swedish steel tube, the relative dimensions varying according to the desired reduction in speed. The necessary pressure to ensure the transmission of motion between *a* and *b* is imparted by a slotted cast-steel clamp ring, *c*, and a cast-iron tightening ring, *d*. These rings have conical contact surfaces, so that when *d* is tightened up by the three equidistant set screws, *e*, the internal diameter of the clamp ring, *c*, is reduced. The rotary motion of the rings, *b*, is transmitted to internal rollers, *f*, which engage with the former in such a manner as to prevent lateral displacement. The force and motion, at reduced speed, are transmitted through the pins, *g*, to the disc, *h*, on the slow-running driven shaft, *i*. The entire system is held together by the enclosed dust-proof and watertight casing, *k*. The pins, *g*, are of steel, and run in bronze bushes; and the oiling is effected by centrifugal force from the main bearing.

**Lighting Trains by Electricity.**—In the "L'Hoest and Pieper" system, which is being worked by the Cie. Internationale d'Electricité, of Liége, the necessary current, says the *Elektrotechnische Zeitschrift*, is supplied from a small steam dynamo, mounted behind the dome of the locomotive, and driven by a double-cylinder engine with invariable cut-off and without governors. The speed, which varies with the load, is about 1,000 revolutions per minute. The dynamo is series-wound and is connected with batteries mounted on each carriage and of sufficient capacity to supply the lamps for three hours. In starting, the dynamo is connected up as a motor, and opens the steam valve, whereupon its functions as a dynamo are resumed, the steam pressure forcing the starting apparatus into such a position that the conductor leading to the carriages is switched into connection with the dynamo terminals. When the carriages are uncoupled, an electro-magnet switches on a resistance in place of the batteries and lamps. In feeding the lamps direct from the dynamo, a resistance is interposed before the lamps, automatically, whilst the lamps in the uncoupled carriages are fed from batteries.

* *Elektrische Bahnen und Betriebe*

The line and return wires are passed from one carriage to another through flexible pipes, and connection is made by plug contacts. The battery chests (16 × 24 × 40 in.) are mounted near the smoke box on the engine, and under the carriage frames.

**Electrically Hauling Goods at a Profit on a Light Railway.**—The electric metre gauge railway between Heidelberg and Wiesloch, which follows the main road to Basle, is a single line eight miles long and has a half-hourly service of passenger trains; in addition to which it conveys some 50,000 tons of limestone per annum from the Nussloch quarries to the Portland cement works at Leimen, three miles away, at a charge of 7½*d.* per ton. This rate is equal to only 1¼*d.* per ton-kilometre, or, allowing for the return trip, ⅝*d.* per ton-kilometre; but the traffic is worked at a profit owing to a combination of favourable circumstances, *inter alia* the fact that the loaded trucks run down an average gradient of 8 per 1,000, though there are two short up grades, one of 1—62, the other of 1—485. The trains have to run at 13½ miles an hour, to work between the regular passenger service, and the locomotives have to be equipped with the necessary fittings to enable them to be used for passenger traffic in an emergency.




ELECTRICAL LOCOMOTIVE FOR HAULING GOODS.

The locomotives are of a novel type, the motors being mounted in the centre of an ordinary truck, the two ends of which serve to carry goods. Two 35-h.-p. motors are arranged on each locomotive, and coupled after the manner of the old "Sprague" system. The current is collected from the overhead wires by two bow trolleys, and each locomotive is equipped with a lighting circuit for four 150-volt lamps, and with connections for the lighting and brake circuits of the passenger trains. Sand boxes, operated by a foot lever, are mounted between the truck wheels. The trucks have saddle bottoms and discharge through the swing sides. The space under the saddle is utilised for the reception of the plate resistances. Both the locomotive and goods trucks are 15 ft. long inside buffers, and their loading capacity is respectively 105 and 175 cub. ft. The tare of the former is 6¼ tons, of the latter 2¾ tons, and their net loads are 4¾ and 8¾ tons. Each train is of three trucks, the total tare being 14¼ tons, net load 31 tons, and gross load 45¼ tons, giving a percentage of tare to net load 46 per cent., and of tare to gross load 31·6 per cent. This compares very favourably with an ordinary goods train: locomotive and tender 68 tons, 40 fifteen-ton trucks, 308 tons; total tare 376 tons for a net load of 600 tons, *i.e.*, ratio of tare to net load 63 per cent. or of tare to gross load 38·6 per cent.

The utilisation of the locomotive truck for carrying part of the train load presents, says the *Elektrische Bahnen und Betriebe*, several advantages. In the first place, 3 tons of dead weight are saved, which would make the proportion of tare to net load 66 per cent., or to gross load 40 per cent. Secondly, it increases the earning power of the train, the revenue from the locomotive load of 4¾ tons in 2,240 train journeys per annum being nearly 20 per cent. of the total earnings from this traffic, and it saves the cost of hauling the aforesaid dead weight of 3 tons each return journey (about £50 per annum), so that the proportion of expenses to receipts would be 42 per cent. instead of 33 per cent. as at present.

**Viaduct and Jetty of Ferro-Concrete.**—To convey the output from the iron mines of Cala, in the province of Huelva, to the Guadalquivir, a little below Seville, a railway has been built about 60 miles in length, with double terminal viaducts and a jetty of ferro-concrete, to cross the low-lying ground, which is subject to floods, between the railway proper and the river bank. The total distance, says *Le Génie Civil*, is about 550 yds., but an embankment 95 yds. long has been thrown up so as to leave only 128 and 79 yds. respectively to be crossed by the viaducts, the longer one having thirteen spans of 29½ ft., and the shorter one nine spans. The girders supporting the rails are 4 ft. high, of TT section 11¾ ft. across the top, the two webs being 9 in. thick. The first six spans describe a curve of 623 ft. radius to reach the embankment. The twin pillars are rectangular, measuring 26 in. × 9 in., the longer side parallel with the track; and the up and down lines vary in altitude at different parts of the viaduct. The two sets of pillars are connected by cross ties at 26 ft. and 36 ft. above the ground level, and the pillars of the line conveying the loaded trucks are tied again 10 ft. higher up. As the rails, one metre gauge, are not vertically over

the girder webs (which are 60 in. between centres), the bottoms of the latter are tied near the heads of the pillars, in order to take up the torsional strain. Each set of four pillars rests on a ferro-concrete foundation 23 ft. long, 70 in. wide, and 8 in. thick, with strong vertical ribs between the pillars; and under this again is a 12-in. layer of ordinary concrete. Under full load on both viaducts the pressure transmitted to the ground cannot exceed 17 lb. per square inch.

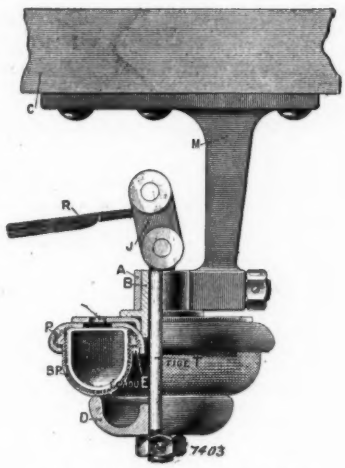
The rails are laid on longitudinal pitch-pine sleepers held by bolts embedded in the concrete girders.

The jetty consists of a platform 49 ft. above low-water mark, and is fitted with a tippler for 15-ton wagons and a 10-ton travelling crane. It is mounted on fourteen ferro-concrete piles, 88½ ft. high, solidly braced together by two stages and horizontal and sloping trusses. Each pile terminates below in an iron shoe, and was allowed to set for two months before being driven. They are spaced 14¾ ft. by 11½ ft. apart, and are connected orthogonally at the height of 40 in. and 33 ft. respectively. The lower platform is built to stand a pressure of 184 lb. per square foot, and is covered with 4½-inch planking. The upper platform will stand a pressure of 740 lb. per square foot, to carry the travelling crane. The two rows of piles surrounding the tippler are strengthened by diagonal braces so as to transmit to the rear piles a portion of the strains set up during tipping; and the ribs carrying the tippler are strengthened against torsion. The tippler is easily controlled and can discharge a truck every 2½ minutes. Another jetty of the same type is to be erected close by, but served only by a single-line viaduct.

**Anti-Vibration Pad for Motor Cars.**—To take up the vibration produced by inequalities in the road, Bernard and Patoureau have designed the pneumatic pad illustrated in the drawing. This appliance* consists of three chief parts, the first being a circular steel plate *P*, forming a channel for the reception of the pneumatic pad *B P*, composed of a tube of D-section, the circular part being directed downward. The third part is a hollowed circular steel plate *D* of special shape, the purpose of which is to transmit pressure to the pneumatic tube *B P* in the most suitable manner and secure complete absorption of the vibration. *C* represents the car frame, *R* the spring, *J* the hanger, and *M* the arm on which the pad is suspended. The plate *D* is connected with the hanger by a rod *T*, which is situated in the central axis of the pad as well as that of the collar *A*, which fits into the supporting arm *M*, so that the pad forms the means of connection between the springs and the car frame. The valve for pumping up the pneumatic tube passes through a hole cut in the plate *P*, for that purpose.

The great advantage of this anti-vibration

* *La Locomotion Automobile.*




ANTI-VIBRATION PAD FOR MOTOR CARS.

pad is that it equalises the load. Thus, a load of one ton on the axle will be balanced by a pressure of 28 lb. in the pneumatic pad; but by pumping the pad up to only 21½ lb., the pad will be just as sensitive in absorbing vibration under a load of only 16 cwt. as under full load. At the same time, the pad takes up shocks that are too small to bend the springs, and thus prevents the vertical movements of the frame that would otherwise occur. It also destroys the vibration set up by the springs themselves, and increases the grip of the tyres on the road, thus minimising side-slip.

## Catalogues Received.

**General Electric Co., Ltd.,** 71, Queen Victoria Street, E.C. Illustrated catalogue of "Witton" single, two and three-phase generators, with stationary armature and revolving field.

**Mather and Platt, Ltd.,** Salford, Manchester. A pamphlet dealing with this firm's system of train-lighting by electricity — known as Rosenberg's patent—which avoids all complications and while possessing the simplicity of the slipping belt method, yet escapes its attendant disadvantages.

**G. W. Hunt, Co.,** New York, U.S.A. Catalogue No. 0510 dealing with the "Hunt" automatic railway now in general use for running coal back from the front of wharf to the storage bin or pocket. It is an elevated, self-acting railway, operated entirely by gravity.

**American Locomotive Co.,** New York City, U.S.A. Special pamphlet devoted to the application of "Walschaert" valve gear to large American locomotives. Also a pamphlet dealing with the "Cole" four-cylinder compound locomotive.

# Metallurgical Progress.

*By PERCY LONGMUIR.*

**High Temperature Measurements.**—In a paper read before the Students' Engineering and Metallurgical Society* Mr. T. Swinden admirably reviews the many methods of measuring high temperatures. Standard pyrometers, as Siemens and Le Chatelier, are fully described, but in view of the practical advantages offered by optical methods, this section of the paper is of greatest interest. Probably the most successful optical pyrometer is that of Wanner, which is based on a photometric comparison of the intensity of light emitted by the incandescent body whose temperature is sought, with the light of a standard lamp. By means of a direct vision spectroscope the light is spread into a spectrum and a small portion of the red examined. A standard light is obtained from a six volt lamp; both sources of light are reduced by polarising in planes at right angles to each other, and the intensity determined by means of a rotating Nicol prism. The angle of rotation is thus made a measure of the intensity of the light, and therefore of the temperature. The lower limit of this instrument is about 900°C., but by the use of smoked glasses it has practically no upper limit.

In the pyrometers of Holborn and Kurlbaum, Morse, Rosenhain and Chalmers, a current through a small lamp is varied by a rheostat until the filament is invisible on a black ground tinted by the radiations of the body under observation. Thence by the current passing through the lamp or by the resistance used, the temperature is indirectly obtained.

**Direct Desulphurisation of Galena by Air Blast.**—In a recent issue of the *Mining Magazine*, Mr. A. Savelsberg describes his process for the direct desulphurisation of galena. The process is founded on the fact that if sufficient limestone is added to lead ore, preliminary roasting can be dispensed with, and it becomes possible to desulphurise the ore in one operation by blowing in air. The action of limestone is partly mechanical and partly chemical. The particles of limestone arrange themselves between the particles of galena and separate the latter from each other. This prevents sintering, and the mass is kept loose and open for the passage of air. The mechanical action of the limestone is assisted by the liberated carbonic acid which also tends to loosen the charge. During the decomposition of limestone heat is absorbed, and as a result the heat generated by the combustion of the sulphur is lowered, which in turn retards liquefaction of the galena. Further retardation is found in the air becoming mixed with carbonic acid, and thereby losing some of its oxidising capacity. Chemically, limestone produces certain reactions. As a result of decomposition, lime is formed which is partly converted into sulphate of lime at the cost of sulphur in the ore. Sulphate of lime is in turn converted into silicate of lime by the silica present, liberating sulphuric acid which acts as an oxidising agent on the sulphur of the ore.

These considerations lead to the actual process which, briefly, is as follows—A mixture of lead ore and limestone containing sufficient silica for the formation of silicates is introduced into a converter, and a current of air blown through. That portion of the mixture adjacent to the tuyere is ignited, and the ensuing reactions result in the formation of lead oxide, sulphurous acid, carbonic acid, sulphuric acid, sulphates and silicates. The lead oxide formed combines finally with the gangue of the ore and the non-volatile components of the additions to give the desired roasted product.

**The Physical and Chemical Properties of Slags.***—Under this heading Professor Turner records an interesting investigation of a typical slag. The sample obtained weighed upwards of six tons, and represented the product of a blast furnace working on all mine iron ores. A vertical section through the block of slag showed distinct differences in colour and texture, the most noticeable facts being:—(a) that the outer shell was lighter in colour and more glassy in character; (b) that the lower central portion was grey and light blue mottled; (c) that the upper central portion, the last to solidify, was of a uniformly creamy appearance. Samples were taken from six positions representing the relative order of solidification, and the analyses are as follows:—

| | Samples in Order of Solidification. | | | | | | Average Composition. |
|---|---|---|---|---|---|---|---|
| | 1. | 2. | 3. | 4. | 5. | 6. | |
| Silica ... ... ... ... ... ... ... ... | 30·10 | 30·24 | 29·35 | 29·30 | 28·74 | 31·16 | 29·81 |
| Alumina ... ... ... ... ... ... ... ... | 19·46 | 19·81 | 21·60 | 20·30 | 21·03 | 18·91 | 19·94 |
| Lime ... ... ... ... ... ... ... ... ... | 40·39 | 39·89 | 40·36 | 39·97 | 39·57 | 41·69 | 40·31 |
| Magnesia ... ... ... ... ... ... ... ... | 2·97 | 2·94 | 2·91 | 2·79 | 2·82 | 3·28 | 2·95 |
| Calcium sulphide ... ... ... ... ... ... | 7·04 | 7·11 | 7·32 | 7·83 | 7·71 | 4·56 | 6·92 |

* Sheffield University.

* *Journal of the Society of Chemical Industry*, No. 22, Vol. xxiv.

The whole of the samples are such as to come between the two types represented by 2 CaO, $SiO_2$, and 3 CaO, $SiO_2$, known respectively as the mono and the subsilicate. The following figures, which represent the relative variations in 100 parts by weight of each constituent, emphasise the changes taking place during slow cooling.

| | Increases per 100 parts of each substance. | | | | | | Decreases per 100 parts of each substance. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. | 2. | 3. | 4. | 5. | 6. | 1. | 2. | 3. | 4. | 5. | 6. |
| Silica ... ... ... ... ... ... | 1'0 | 1'5 | — | — | — | 4'5 | — | — | 1'5 | 1'7 | 3'6 | — |
| Alumina .. ... ... ... ... ... | — | — | 1'1 | 1'3 | 5'3 | — | 2'5 | 0'7 | — | — | — | 5'2 |
| Lime ... ... ... ... ... ... | 0'2 | — | 0'1 | — | — | 3'5 | — | 1'1 | — | 0'9 | 1'9 | — |
| Magnesia ... ... ... ... ... | 0'1 | — | — | — | — | 1'1 | — | 0'0 | 0'1 | 0'5 | 0'4 | — |
| Calcium sulphide ... ... ... .. | 1'7 | 2'7 | 5'7 | 13'0 | 11'3 | — | — | — | — | — | — | 33'7 |

These figures indicate no important separation of silicates of lime or alumina such as might be expected if the slag were of the nature of an eutectic mixture with an excess of some other constituent. However, it will be noted that the last fluid portion, No. 6, contains only 66·3 parts of calcium-sulphide per 100 parts present in the original slag. This loss is not due to volatilisation or oxidation, for it will be noted that the loss in one part is accompanied by a corresponding and gradual increase of sulphur in samples three, four, and five. Alumina is highest in the parts containing most sulphur, and these parts also had the most marked blue colour. This supports the suggestion that the blue colour of the blast furnace slag is due to some form of oxysulphide of alumina. The sulphur results show that the changes taking place during cooling are merely due to sulphur exchange owing to the alteration in the conditions of equilibrium as the temperature gradually fell. In view of the very exact melting points of certain slags which have been published from time to time, it was anticipated that cooling curves would yield some interesting data. However, notwithstanding the precautions adopted the cooling curves showed no signs of eutectics, and no distinct line could be distinguished between the fluid, plastic and solid state. Under these circumstances, outside assistance was sought. and the results may be summarised as follows :—

Messrs. Hudson and Picken (Birmingham University) began 1,345 °, ended 1,215 °C.
Dr. Carpenter (National Physical Laboratory) began 1,253 °, ended 1,140 °C.
Dr. Rose (Royal Mint) began 1,175 °, ended ?

Therefore, in view of these erratic results, it is concluded that the slag had no melting point but has a wide melting range. In conclusion, it is shown that silicate slags are heterogeneous mixtures, which, though fusible at high temperatures, have no definite melting point. They usually contain three constituents, viz., (1) a relatively inert solvent or matrix formed of one or more fusible silicates; (2) an active agent dissolved in the solvent and usually consisting of a metallic oxide or a mixture of oxides; (3) the product of the action of (2) on some characteristic impurity in the charge, the proportion of which impurity entering into the metal determines its quality. At high temperatures this gives a system including four phases, and the results, though complicated, are such as can be determined by the application of the phase rule.

**Alloys of Iron and Nickel found as Natural Minerals.**—Mr. G. S. Jamieson gives in the *American Journal of Science* the following analyses :—

| No. | Iron. | Nickel. | Cobalt. | Copper. | Phosphorus. | Sulphur. |
|---|---|---|---|---|---|---|
| 1 | 25'42 | 74'17 | 0'46 | nil. | 0'04 | 0'09 |
| 2 | 21'45 | 76'60 | 1'19 | 0'66 | 0'04 | 0'06 |
| 3 | 31'02 | 67'63 | 0'70 | nil. | 0'04 | 0'06 |
| 4 | 26'60 | 73'20 | — | nil. | 0'04 | 0'06 |
| 5 | 27'41 | 71'35 | 0'65 | 0'59 | nil. | nil. |
| 6 | 22'30 | 76'48 | nil. | 1'22 | nil. | nil. |

No. 1 is Josephinite from Josephine County, Ore., found as water worn pebbles, consisting of the alloy in a spongy form and enclosing particles of serpentine; No. 2 is a similar alloy from Smith River, Del Norte County, Cal., and is found as a metallic sand with grains of uniform size obtained from gold washing; No. 3 is Awarnite from New Zealand; No. 4 is a terrestrial alloy from Piedmont; No. 5 is Josephinite from Oregon; No. 6 is Louesite from British Columbia.

**A Co-operative Analysis of a Copper Slag.***—This report represents a second effort by Mr. Thorn Smith towards the production of better chemical work. The object is solely to make better chemists and to show the need for more accurate work by practical demonstration. To this end a standard sample of copper slag was sent to various chemists,

* *Electro-Chemical Metallurgical Industry*, November and December, 1905

and the reports submitted are discussed at length. This discussion is of chief interest to the analytical chemist, but the conclusions of the report are of very direct general interest. From these conclusions we select the following :—The writer has several times stated that the methods of teaching were at fault, and his statement has been abundantly borne out through numerous letters received from his co-operators. A professor of chemistry whose hobby is organic chemistry, is liable to be a poor teacher of inorganic, and especially of analytical chemistry. Too often he is desirous of following out an interesting derivative, and in such cases his inorganic classes are taught by inexperienced instructors. The student graduates and in turn becomes an instructor. While this man's theoretical knowledge may be unquestioned, something more is required to make a working analytical chemist. In short, too much is delegated to an instructor whose training is but little above that of the student he is endeavouring to teach. Professors are frequently employed whose chief recommendation is a doctor's degree. Further, the writer finds an evil in the indiscriminate publication of research, by students especially, in applied chemistry. False conclusions, often the result of poor analytical work, are drawn, and these must in time reflect on the school from which they emanated. Not only so, but such articles are a source of annoyance to the working chemist who may wish to apply the conclusions.

**Prehistoric Metal from Nancy.**—MM. G. Arth and P. Lejeune record in the *Revue de Métallurgie* their examination of a sample of ancient metal found in the neighbourhood of Nancy. The mass weighed about 300 kg., it was found at a depth of 4 m. 50, and was associated with fragments of carbon and debris, the latter having the appearance of slag. The mass was formed of alternate layers of metal and slag, and gave every indication of being the product of an old metallurgical furnace. An analysis of the metal showed it to contain :—

| | |
|---|---|
| Combined carbon ... ... ... | 1·212 per cent. |
| Graphite ... ... ... ... | 0·038 ,, |
| Silicon ... ... ... ... | 1·670 ,, |
| Sulphur ... ... ... ... | 0·026 ,, |
| Phosphorus ... ... ... ... | 0·013 ,, |
| Manganese ... ... ... ... | 0·180 ,, |

The contents of combined carbon places the metal in the class of steel. Silicon is notably high, a feature due to the strongly acid character of the slag, which contains 63·9 per cent. silica. Chemical and micrographic studies place the metal in the first category of silicon steels studied by Guillet, *i.e.*, pearlitic steels plus a solid solution of $F_2Si$ in iron. The metal is distinguished by its macroscopic structure, which is in agreement with the consecutive annealings and slow coolings to which it has been submitted.

## FOUNDRY PRACTICE.

**Open Hearth Steel Castings.***—In this, the first of a series of articles, Mr. W. M. Carr discusses materials used in the acid and basic processes. Types of pig iron, alloys, refractories and fuels are fully treated. Moulding materials by the nature of the case must be as refractory as possible. Pure silica bonded with fire clay is the most suitable. Typical analyses are as follows :—

| | Silica Sand. | Fire Clay. |
|---|---|---|
| Silica ... ... ... | 98·50 ... | 60 to 66 |
| Alumina ... ... | 1·40 ... | 20 to 25 |
| Iron oxide ... ... | 0·06 ... | nil to 2·0 |
| Lime ... ... ... | 0·20 ... | nil to 1·0 |
| Magnesia ... ... | 0·16 ... | nil to 1·0 |
| Alkalies ... ... | 0·25 ... | nil to 2·0 |
| Combined water ... | 0·14 ... | 7·5 to 10·5 |

The value of a fire clay is largely determined by a low content of alkalies and freedom from carbonate of lime. Iron oxide is strongly fluxing, but is not dangerous when below 3 per cent. In concluding this instalment, the writer gives a table showing the approximate amount of materials required to produce one ton of castings by either process.

| Material. | Acid Process. lbs. | Basic Process lbs. |
|---|---|---|
| Pig iron ... ... ... | 620 ... | 1,227 |
| Steel scrap ... ... ... | 1,880 ... | 1,227 |
| Ferro silicon ... ... | 54 ... | 57 |
| Ferro manganese... ... | 28 ... | 33 |
| Iron ore ... ... ... | 26 ... | 30 |
| Chrome ore... ... ... | — ... | 5 |
| Aluminium ... ... ... | 0·3 ... | 0·3 |
| Limestone ... ... ... | — ... | 300 |
| Dolomite ... ... ... | — ... | 85 |
| Fluor spar ... ... ... | — ... | 13 |
| Magnesite ... ... ... | — ... | 34 |
| Silica sand ... ... ... | 1,800 ... | 1,600 |
| Fire clay ... ... ... | 300 ... | 350 |
| Gas coal ... ... ... | 950 ... | 1,250 |
| Fuel oil ... ... ... | 55 ... | 80 |
| Boiler coal (Power) ... | 900 ... | 900 |

It will be noted that this table includes material for the charge, fluxes, repairs to linings and moulding materials all calculated on the basis of production per ton of castings.

**Cost of Air Furnace and Cupola Castings.**—Mr. L. G. Blunt * contends that the cost of melting iron in an air furnace as compared with the cupola is not as expensive as often pictured. In a large foundry making heavy castings the labour on air furnaces amounts to about three cents per ton more than on cupolas, whilst repairs on the former exceed the latter by about seven cents per ton. Against this fuel costs are eight cents per ton lower for air furnace metal than for cupola metal. Cupola castings to have the same strength as air furnace metal require charcoal pig iron, and this gives the air furnace a decided advantage over the cupola. Further, the composition is under more control in the air furnace and a certain amount of regulation is possible.

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*The Foundry*, December, 1905.

**On the Manufacture of Chilled Rolls.**—The December issue of the *Revue de Métallurgie* opens with an interesting article on chill and grain rolls by M. E. de Loisy. The manufacture of rolls, especially chilled ones, is largely empirical, therefore experimental studies in this direction are desirable in order that the results may offer some scientific guidance to the founder. To this end the author gives a method which has yielded good results in several works. Taking unchilled rolls first, success is summed up in (1) addition to the cast iron of a certain amount of steel, and (2) a phosphorus content of about 0·5 per cent. The amount of steel should be such as to reduce the total carbon to between 2·5 and 2·8 per cent. In any case, total carbon should be below 3 per cent. If necessary, phosphorus is added by the use of a phosphoric pig iron. The scientific rôle of phosphorus is not well defined, but it appears to give a homogeneous iron, close in grain and to favour the even distribution of graphite. Such an iron will present a normal hardness and give a regular wear in the grooves of the roll without showing any disposition to shell. In melting steel scrap with cast iron the reverberatory furnace is the best, in that, one melt will give a homogeneous metal suitable for direct casting. With either an ordinary air furnace or a Siemens Martin furnace the bath may be sampled before casting and any necessary additions made. When the cupola furnace has to be used the scrap steel and cast iron do not readily mix, further, the separate charges are apt to vary, and the resulting product is by no means uniform. Whilst under certain conditions a fair mixture may be effected in one fusion, the author strongly advises remelting in order to obtain a result. The first cast is arranged so that after casting the pigs shall give :—

| Silicon. | | Manganese. | | Phosphorus. |
|---|---|---|---|---|
| 0·55 | ... | 0·60 | ... | 0·35 |

Allowance must be made for silicon and manganese losses, and a slight concentration of phosphorus. Carbon should be reduced to about 2·3 per cent. by the addition of steel scrap. This mixture is poured into small pig moulds, and the pigs when cold are broken, and the fractures examined. If required, further additions are made on re-melting, which should give the following product :—

| | Total carbon. | Silicon. | Manganese. | Phosphorus. |
|---|---|---|---|---|
| In the vicinity of | 2·65 | 0·4 to 0·5 | 0·6 to 1·1 | 0·5 |

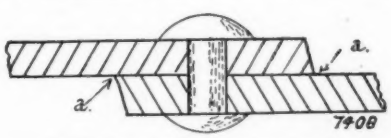
Sulphur should be as low as possible, and according to district this may require the use of special coke. As for the mixture to produce this ideal composition one must necessarily employ the materials at hand, the essentials are (1) grey non-phosphoric pig iron, (2) basic pig iron for phosphorus, (3) spiegel for manganese, and (4) steel scrap. Typical mixtures founded on the foregoing are quoted and are stated to have been employed in the North of France for the last twenty years. In the case of chilled rolls the composition sought should be between the ollowing limits :—

| | | | | |
|---|---|---|---|---|
| Total carbon | ... | ... | ... | 2·90 to 3·00 |
| Silicon | ... | ... | ... | 0·70 to 0·90 |
| Manganese | ... | ... | ... | 0·50 to 1·00 |
| Phosphorus | ... | ... | ... | 0·35 to 0·45 |

Here again, the addition of steel scrap to pig iron is advocated, but less amounts will suffice, and usually an addition of 15 per cent. will meet all requirements. Owing to the less amount of scrap used the mixture may be passed directly through the cupola, thus dispensing with the preliminary pigs. The composition of the chills should be similar to that of a good ingot mould, *i.e.*, a cast iron containing the lowest possible sulphur and phosphorus, with about 2 per cent. silicon and manganese below 1 per cent. A good chill will generally give about sixty casts. In casting, hot metal is advised for sand rolls, whilst for chill rolls the metal should be as dull as is consistent with fluidity.

## STEEL, ITS PROPERTIES AND TREATMENT.

**Channels of Corrosion in Boiler Plates.***—At the outset the authors review the general conditions of corrosion, specially noting the effect of carbonic acid. Faults committed whilst working the steel or during construction of the boiler, may lead to internal defects which offer a starting point for corrosion. However, the authors specially examine the result of deformation in service and the subsequent influence of this deformation on corrosion. Taking deformation first, it is shown that the stresses developed in a boiler under service conditions are to some extent localised owing to the impossibility of uniform distribution of stress. For example, a bar, one end of which is embedded in a block, will on flexure of the free end show the greatest deformation at the immediate junction of the bar and block. Thus, in the case of a boiler where two flanges are superposed for riveting, as in the accompanying figure, the double thickness produces a reinforcement, and the single plates may be considered as encased at a,a. It is at these points that there will be a risk of exceeding the elastic limit. Other examples are given which go to show that wherever a reinforcement is made the immediate locality presents a place of possible maximum deformation, and as shown by experience, these points are the most




CHANNELS OF CORROSION IN BOILER PLATES.

* MM. Frémon and Osmond, *Revue de Métallurgie.*

corroded. Apparently this would lead to the conclusion that the localities most fatigued lead to a type of crystalline deformation which is readily acted on by a corrosive agent. However, an objection to this conclusion lies in the fact that the grooves of corrosion are a constant phenomenon whilst crystalline deformation is not necessarily constant. A boiler plate, presumedly homogeneous submitted to uniform oxidation will oxidise equally, and a uniform and progressively increasing layer of oxide will form on the plate. As this oxide is undeformable it will reach a state when elastic flexion of the plate will determine its rupture. This will occur in regions most fatigued, following lines of which the direction is a function of that of effort. Repetition exposes fresh surfaces for attack, and the deepening of the grooves is continued whilst other parts of the plate are protected by undetached oxide.

**Nickel-Vanadium Steels.**—M. Guillet prefaces his memoir* with summaries of his earlier researches on nickel steels and vanadium steels, both of which have been noted in these columns. In the simultaneous presence of nickel and vanadium one would naturally expect a series of interesting alloys, and it is to be regretted that M. Guillet in following a somewhat stereotyped plan has not more exhaustively examined these alloys. However, taking the paper as it stands we note that micrographic examination of a large series of normal steels leads to the conclusion that no less than six classes of nickel-vanadium steels may be defined.

(1) Pearlitic.
(2) Steels of carbide and ferrite.
(3) Martensitic steels.
(4) Martensitic steels enclosing carbide.
(5) Steels of $\gamma$ iron.
(6) Steels of $\gamma$ iron enclosing carbide.

The mechanical properties are summarised in the following tables:—

* *Revue de Métallurgie.*

These tests show that in the case of pearlitic steels progressive increments of vanadium up to 1 per cent. increase the maximum stress, and with vanadium exceeding 1 per cent. the maximum stress decreases. This supports the micrographic results in that the appearance of carbide corresponds to a clear diminution in the resistance offered to shock. Martensitic steels are equally affected by the presence of vanadium in that maximum stress increases without a corresponding increase in fragility. Martensitic steels enclosing a small amount of carbide are not very fragile, neither is the hardness extreme, features probably due to the formation of carbide of vanadium which localises the carbon. Maximum stress in the case of steels of $\gamma$ iron is not sensibly modified, elongation and resistance to shock are lowered. It is worthy of note that in all classes the maximum influence of vanadium is obtained with a content of 1 per cent. vanadium.

Examination of a second series in which the average carbon is given as 0·8 per cent. leads to conclusions fairly similar to those drawn from the first series. Finally, in comparing the properties of nickel-vanadium steels with those of nickel steels it shows that the effect of vanadium lies in raising the elastic limit and maximum stress, a feature specially marked in pearlitic steels. This increase, however, reaches a maximum corresponding to the maximum amount of vanadium dissolved in the steel before the appearance of free carbide. Quenching experiments have shown that the structural changes are as follows:—Pearlitic steels become martensitic, martensitic steels remain unchanged, but show a tendency to $\gamma$ iron; steels of $\gamma$ iron are also unchanged. Steels enclosing carbide, irrespective of class, preserve integrally their carbide, and this holds good for any quenching temperature. Mechanical tests of the steels quenched from a temperature of 850° in water at 20°C. show that in the case of pearlitic steels, elastic limit and maximum stress are very considerably increased. This increase is associated with comparatively high

| Carbon. | Nickel. | Vanadium. | Elastic Limit. | Max. Stress. | Elongation per cent. | Shock Frémont. | Hardness Brinell. |
|---|---|---|---|---|---|---|---|
| 0·261 | 2·32 | 0·35 | 55·2 | 66·3 | 21·5 | 31 | 187 |
| 0·151 | 2·04 | 0·60 | 44·6 | 60·3 | 20·0 | 40 | 170 |
| 0·151 | 2·00 | 0·75 | 49·4 | 64·1 | 23·5 | 30 | 159 |
| 0·230 | 1·92 | 1·00 | 65·2 | 84·5 | 22·0 | 28 | 259 |
| 0·473 | 2·32 | 3·10 | 64·0 | 72·3 | 16·0 | 16 | 217 |
| 0·384 | 2·64 | 6·90 | 44·8 | 60·8 | 17·5 | 5 | 183 |
| 0·140 | 12·24 | 0·25 | 115·2 | ?* | 6·0 | 7 | 351 |
| 0·164 | 12·20 | 0·60 | 120·0 | 135·7 | 6·0 | 12 | 321 |
| 0·199 | 11·76 | 0·90 | 121·9 | 142·7 | 6·0 | 9 | 340 |
| 0·258 | 12·16 | 0·98 | 123·4 | 155·1 | 6·0 | 8 | 364 |
| 0·209 | 11·44 | 3·30 | 81·0 | 91·2 | 7·5 | 10 | 277 |
| 0·265 | 11·96 | 7·35 | — | 110·5 | 5·5 | 7 | 286 |
| 0·152 | 29·84 | 0·35 | 32·5 | 52·6 | 20·5 | 43 | 116 |
| 0·242 | 29·76 | 1·05 | 44·2 | 69·2 | 25·0 | 40 | 143 |
| 0·242 | 30·00 | 1·20 | 48·6 | 68·4 | 20·0 | 35 | 156 |
| 0·361 | 29·56 | 3·03 | 44·2 | 65·9 | 20·5 | 22 | 159 |
| 1·269 | 30·48 | 6·76 | 13·0 | 59·8 | 28·5 | 20 | 134 |

*Given in the text as 12·8.

elongations and resistance to shock. Martensitic steels are hardened by quenching, but to a less extent than the pearlitic steels. Steels of $\gamma$ iron show an interesting feature in that, after quenching elastic limit and maximum stress are not diminished, whilst elongation and resistance to shock are somewhat improved. Annealing does not induce any particular change; it is, however, noted that grains of carbide, when present, increase in volume by this treatment.

To some extent the steels are slightly softened, but elongations diminish and fragility increases. A series of results obtained from steels annealed for a period of four hours at 900°C. are quoted. Cementation experiments have not yielded any abnormal results. If the content of vanadium is high and cementation prolonged then grains of carbide of vanadium appear.

## Book Reviews.

**Elementary Practical Metallurgy, Iron and Steel.** By PERCY LONGMUIR. 270 pages and illustrations, and 13 plates. Crown 8vo. (Longmans, Green & Co.) Price, 5s. net.

THE name of the author of this work needs no introduction to the readers of the Review. He is also well known here and in America as a prolific writer on metallurgical and especially foundry subjects, in various technical magazines. His own practical experience in foundries and his research work will inspire confidence that the subject will be handled in a manner showing a full measure of sympathy with the man who is doing the work, who is actually engaged in the fashioning of metals for commerce, whether by the hammer or by the lathe, whether as metallurgist or as engineer. The preface tells us that the work is designed for the beginner, primarily to awaken interest, therefore not overloaded with details but yet to be accurate and the matter reliable. The writer judges that the author has in the main been successful in carrying out his aim. It is a book which should appeal to the hitherto severely practical man in the works who feels he would like to begin a study of his subject's literature, but it should also appeal to the young engineer who would like to know something of the manufacturing and inner structure of the metals with which he deals, and thus perhaps avoid asking for material to unreasonable specification. To such, the chapters on the production and general properties of cast iron, the cast irons available, the remelting and mixing of the same, and the production and general properties of malleable cast iron, will be of special interest. Wrought iron still holds its chapter, and rightly so, but the statement on p. 135 that an important difference between wrought iron and steel is that the latter on quenching "assumes an adamantine hardness" is not a good one to place before the engineer of to-day, for the structural steels will not harden and although the true definition of steel bristles with difficulties the fact that wrought iron as such was never in a molten state but formed in a pasty condition and therefore always contains involved cinder, whilst steel will either harden as mentioned or has been cast direct into malleable masses seems about the best for general modern use. The chapters on steel and its manufacture by the crucible, open hearth and Bessemer processes are all of interest, and that on the production of sound steel is admirable. Surely it would pay young engineers to study these well with Chapters XVIII. and XIX. on the metallography of heat treated and of hardened steels to see that steel is not one thing only but a multitude of metals in itself, and the final chapter on special steels should whet the appetite and produce a strong desire to know more of the wonderful effects of the addition of special elements. Some of the author's definitions are perhaps a little lax, and here he may be supported by engineers against your reviewer, but is it not time that "breaking load" instead of "maximum stress" should be finally dropped, as what is measured in this country at least is the maximum stress and not the breaking load, which in a ductile material is much less? Ductility is given two distinct meanings, and the present writer still hopes that metallurgists old and new may soon abandon their special definition and leave only that common to engineers and metallurgists. Ductility as understood by engineers is the property which enables a metal to be permanently *drawn out* by a simple tensile stress after its limit of elasticity is passed, whereas the degree to which a metal may be drawn into wire is a function of two well-known properties, tenacity and malleability. There is a good index, the book is clearly printed on nice matte paper, while the photomicrographs, from the author's own negatives, are beautifully reproduced on special paper. The work can be confidently recommended to the rigidly practical man, to the young engineer, and to the beginner in the study of the metallurgy of iron and steel.

**The Application of Electric Motors to Machine-Driving.** By ANDREW STEWART, A.M.I.E.E. Third Edition, revised and enlarged. 1905. (London: S. Rentall & Co., Ltd.) Price, 2s.

Mr. Stewart provides in this little volume much useful information and sound instruction for power-users regarding electric driving. It is evident that his work is appreciated, as a third edition is now demanded, and a comparison of the apparatus described and illustrated in this new edition with that which appeared in the first edition affords striking evidence of the rapid advance that has been made in this branch

of practical science, and shows that Mr. Stewart has taken trouble to make his selections up-to-date and representative. The subject of electric driving of machines, however, cannot be explained merely by illustrations and descriptions of motors attached to different types of machine, and the real merit of Mr. Stewart's work is found in the little practical notes and hints which show the writer to be a man speaking from sound knowledge and wide practical experience of his subject. Mr. Stewart is writing primarily for power users, and not for electrical engineers. He knows that what the power user wants to learn is, What will be the economy gained by introducing electric driving; and he therefore gives this question very careful attention, discussing very fully the advantages of electric driving over that by steam or gas engines, and illustrating his arguments by actual results obtained. In subsequent chapters he considers the application of electric power to machine-driving in various different industries, *e.g.*, in shipbuilding and engineering works, printing works, textile and paper factories, wood-works, and clothing factories. The book is copiously supplied with illustrations, and constitutes altogether a thoughtful and useful contribution to the literature on the subject. It may be cordially recommended to users of heavy or light machinery.

**Mechanics for Engineers. A Text-book of Intermediate Standard.** By ARTHUR MORLEY, M.Sc., Senior Lecturer in Engineering in University College, Nottingham. 1905. (London: Longmans, Green & Co.) Price, 4s. net.

In this book the author has endeavoured to give a course of instruction in mechanics, specially adapted for the needs of engineering students, and of such length as to enable the student to master it in one year's study. We have examined the whole course very carefully, and it appears to us to be suitable, well arranged, and excellently written. Without using the calculus, the author works out all the equations and formulas which the student must use, and shows how they are applied in practical problems. The exercises given in the text and at the ends of chapters are excellently chosen for the purpose of making the student apply the knowledge he has just gained, and at the same time realise the importance of that theoretical knowledge by having it applied at once to practical problems.

The discussion of kinematics and the laws of motion occupies the first two chapters. Chapter III. deals with work, power, and energy; and Chapter IV. with motion in a circle and simple harmonic motion. The author then turns to statics, special chapters being devoted to statics of rigid bodies, centre of mass, and centre of gravity. Chapter IX. gives an outline of moments of inertia, and the concluding chapter is devoted to a discussion of the elements of graphical statics.

From this description it will be seen that the contents of the book are of the usual type; they cover ground which many writers have already covered; but the author's treatment of the subject appears to us to be at once readable and reliable, and, taken in conjunction with the exercises, should be found suitable for engineering students, especially if they be reading for the Intermediate (Engineering) Examination of London University.

**Civil Engineering.** By T. CLAXTON FIDLER, M.Inst.C.E., Professor of Engineering, University College, Dundee, in the University of St. Andrews. 1905. (London: Methuen & Co.) Price, 2s. 6d. net.

Professor Claxton Fidler has been most successful in writing the story of civil engineering, which this little volume contains. He traces the origin of civil engineering in Britain and its progress up to the present time, and thereafter deals more particularly with the work which a civil engineer may be called upon to do, and the training and education necessary to qualify him for that work. The author writes in an easy and attractive style, which makes all that he has here written very readable. In the chapter on education he chooses for illustration of a suitable course that given in Dundee to his own students—a course which is now almost uniform in all the Scottish Universities, and is excellently suited for the training of engineers. Technical college courses are also noticed by the author, who has, however, a strong predilection in favour of the universities. This is a natural view, and there can be no doubt that, while technical colleges do good work, they cannot fulfil the functions of a university. Professor Fidler's views on education appear to us to be very sane, and may be commended to the notice of engineers. The concluding chapter of the volume gives a short sketch of the Institution of Civil Engineers, which every engineering student should endeavour to join.

The volume is excellently printed and has good illustrations. It is a welcome addition to the list of Messrs. Methuen's "Books on Business."

# Electrical Notes.

*BY ANDREW STEWART, A.M.I.E.E.*

**Electric Power from the Victoria Falls.**—Perhaps the most interesting and debatable subject of the last few weeks has been the project to supply the power requirements of the Rand from the Victoria Falls, one of the few waterfalls in the world which can, with Niagara, be classed as an enormous source of power. Unlike Niagara, there is no convenient market for power generated at or near these falls, the nearest being the mining industries of the Rand, which are roughly 700 miles distant. The scheme, which has just been proposed by Mr. H. Wilson Fox and discussed in many journals, is to deliver at first some 20,000 horse-power at the Rand, the supply being ultimately developed until the requirements of the mining industry, estimated at 150,000 horse-power, are met.

The hydraulic part of the scheme presents no difficulties not already met and overcome in the Western States of America and at Niagara, and the interest of engineers centres on two points, the transmission line and the still more important consideration, will it pay? So far as the question of transmission is concerned, the project involves two considerations which are mutually dependent on each other, viz., the magnitude of the line loss and the voltage. The former influences the capital charges, for, assuming that the proposed line loss, viz., 25 per cent., will be adhered to, another 10 per cent. at least will be lost in transformation, for the pressure necessary to transmit the required horse power with any degree of economy over that distance must be anything from 50,000 to 70,000 volts, which will have to be transformed down at the receiving end to a suitable pressure, thus involving capital investment in transformers and transformer houses, with their charges for interest on capital.

To deliver 20,000 horse-power will require about 30,000 horse-power supplied to the line at the falls, which at £11 per horse-power installed would mean about £330,000, while a further £6 per horse-power would have to be sunk in the transforming plant and buildings. If we take a reasonable amount for contingencies, we have somewhere about half-a-million as the probable capital cost of the plant. The most formidable item is the line and whether on a high-pressure direct-current system, as advocated by Professor Ayrton, or a more orthodox three-phase system, the cost is likely to be between two and two-and-a-half-million pounds, as the promoters propose a duplicate line, either of which will be capable of transmitting the total power. It appears from the paper read by Mr. Hammond before the British Association in Johannesburg that such a plant, with a load factor of 40 per cent. and a diversity factor of 1·65, would be able to deliver about 88 million units per annum, so that assuming the capital to be 2½ million pounds, and 7½ per cent. on the capital to meet interest, depreciation, and similar charges, the fixed charges on the undertaking cannot be less than ·51*d.* per unit, or ·38*d.* per horse-power hour. This price is quite irrespective of the cost of distributing the power among users on the Rand, for it only includes energy delivered at the low pressure side of the transformer house.

One must add distribution and labour costs at the generating and sub-stations, and the cost of patrolling a line 700 miles long, for even assuming that it runs parallel to a railway, the distance is so great that several depots with a staff and the necessary material for repairs will have to be established. In a country where mechanics earn from £5 to £7 per week, and where the materials employed are also expensive, these items can hardly be overlooked, and it seems improbable that all other charges can be met for less than ·2*d.* per kilowatt hour or a total cost of about ·7*d.* per unit (·52*d.* per horse-power hour).

One must bear in mind that power so delivered has to compete with coal at 10*s.* to 12*s.* per ton; indeed, it can be obtained at 5*s.* per ton at the pit's mouth, though the establishment of a generating station at the pit's mouth would involve a comparatively short transmission line. In view of the fact that in a very large power house fuel would, at most, only be half the total power expenses, and might not even reach this figure, as will be evident from a scrutiny of the accounts of some of the largest steam driven power houses, this might not therefore be justifiable, as the charges on the transmission line would probably cancel the saving in coal. Moreover, a gas-driven electric station could, with coal at 10*s.* per ton, deliver a kilowatt hour at the bus bars for anything from ·11*d.* to ·135*d.* per unit, equal to a consumption of 1·3 to 1·6 pounds of coal per brake horse-power hour, which is none too favourable to the gas engine. The confidence of engineers in gas-driven generating stations is apparent from the fact that Messrs. Mordey and Dawbarn are at present erecting a 13,000 horse-power electric power station in Johannesburg, equipped with "Oechelhaeuser" gas engines made by Messrs. Duncan Stewart & Co., Glasgow. The standing charges on such a station would probably be no greater than that necessary for the hydraulic power house, so that the very large outlay on the line would be eliminated.

It must not be forgotten, in discussing a project of this nature, that most of the successful hydro-electric plants have been developed to supply power in districts where coal is much more expensive than it is on the Rand, hence there was a wide economic margin between the two powers; but with coal of fairly good quality at the price named, the prospects of a gas or even a steam plant on the spot can only be described as good.

We should be the last to discourage electric

power schemes of this kind, but the moral and intellectual damage, to use the phrase of a late head of a now defunct republic, which the failure of such a scheme would inflict on the electrical industry, and particularly on more promising schemes of electric power transmission, makes one pause before doing anything to encourage what appears to be, in view of the low cost of fuel on the Rand, an ill-considered scheme.

**An Electrically Operated Blast Furnace Hoist.**—Messrs. W. Lahmeyer & Co., of Frankfort-on-the-Main, have recently completed an electrically operated fuel and ore hoist of the double-girder sloping type, shown in Fig. 1. The fuel and ore comes in separate wagons, and ore and coke are handled alternately—when one truck is at the top of the hoist the other is at the bottom. Each truck weighs about two tons, and lifts four tons of ore or two tons of fuel. The vertical height of the lift is 130 ft., and the time taken per trip is 1¼ minutes.

The control of the lift is automatic, the cutting out of the resistance during the period of acceleration being effected by means of a drum controller operated by the driving mechanism. Fig. 2 shows the general arrangement of the gear and winding drums. The operating wheel is seen in the centre, the chain gear operating the controllers, one on either side for each driving motor, will be noted. There are two 100 h.-p. motors which run at a speed of 290 revolutions per minute, geared to each drum, and they are so connected that either motor may drive either winding drum, or both may be used to drive one winding drum. The latter is necessary when, for instance, one truck has to be lifted, unassisted by the descending truck, which would be the case if one of the countershafts or a rope were broken. Brakes are fitted to each motor, and emergency strap brakes, one of which can be seen (Fig. 2), are fitted to the winding drum; the former are electro-magnetic and similar to those usually fitted to electric cranes, which operate immediately the current is switched off or the circuit is interrupted. Should the truck be overwound, the depth indicator withdraws a plug from beneath the emergency brake lever and allows it to fall, thus applying the brake. The usual bell signalling gear is also fitted.

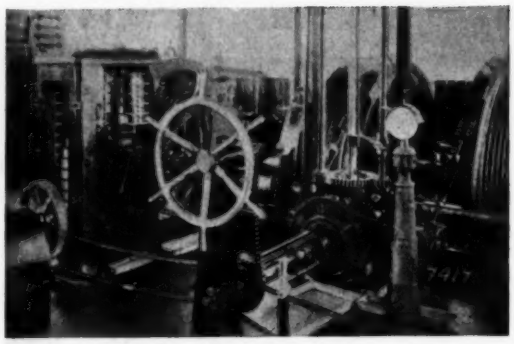


FIG. 2.—GENERAL ARRANGEMENT OF GEAR AND WINDING DRUMS.

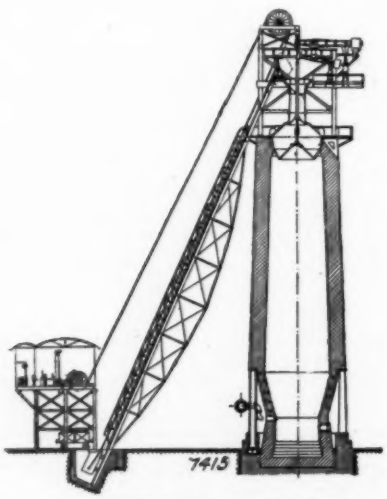



FIG 1.—ELECTRIC BLAST FURNACE HOIST.

Retardation is effected by reversing the motors and making them act as dynamos, which gives a braking effect proportional to the velocity of the load, though in addition a friction-retarding gear is fitted.

**Electric Haulage on Canals.**—In view of the declaration of the Prime Minister that a Royal Commission on Canals will be appointed, interest in our inland waterways will be revived. It is true that a section of the engineering public have always advocated the more extensive use of canals for the transport of such goods as are imperishable, and where delivery is not a matter of serious importance. While, of course, many of our canals are by no means unused, the chief difficulty has been that they have not been kept up-to-date. Our two great European industrial rivals, Belgium and Germany, have, on the other hand, made every effort to keep their system of canals abreast of the times, and there seems no doubt as to their value in fostering the internal trade of these countries. The remarkable development of

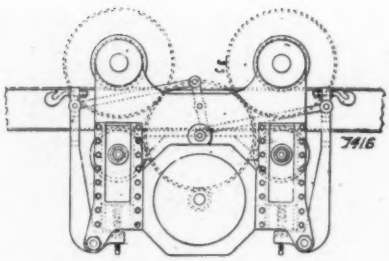



FIG. 3.—ELECTRIC CANAL TRACTOR.

canal transit will be apparent from the fact that during the last decade the cost per ton mile for goods transported on these inland waterways has fallen by from 20 to 50 per cent., due to the introduction of larger barges and, in many cases, mechanical haulage.

Of course, one must not forget that these countries are exceptionally well favoured by nature, inasmuch as they possess great natural highways in the shape of rivers such as the Rhine, Elbe, Weser, Meuse, Scheldt, Dendre, &c., and that the canals have in most cases been constructed as a means of intercommunication between these rivers. The fact, however, that the rates for the transport of such materials as bricks, coal, ore, &c., is about 50 per cent. lower than by rail, shows what an important part these waterways play in the internal economics of the country.

Tugs and mechanical tractors have been used for quite a long time, and some of our readers will no doubt be acquainted with the traction engine which has been tried on several canals in this country with a view to replacing horse haulage. Electric traction is in use on a short section of one of these canals, and it has also been tried on the Erie Canal, U.S.A. The chief disadvantage of these tractors running on rails is the liability of the wheels to skid, especially at starting and during acceleration, for it must be remembered that, in addition to a heavy barge, a large body of water must be put in motion. The latest attempt to get over this difficulty is by means of the proportionate adherence tractor (Fig. 3) which runs on a girder of H. section. An experimental track has lately been erected along the canal bank near Schenectady, N.Y., the girder on which the tractor runs weighs 80 lbs. per yard, having a depth of 10 in. with extra heavy flanges, and is carried on lattice girder columns. Such a track has the advantage that it takes up little space on the canal bank, and does not preclude the employment of horse or other haulage from the canal bank.

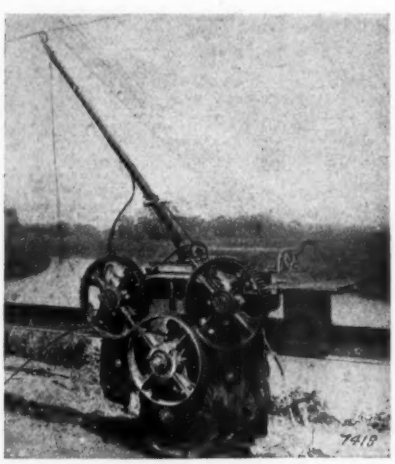



FIG. 4.—ELECTRIC CANAL TRACTOR.

The towing rope is fastened to the hooks seen at either end of the carriage It will be apparent from the drawing that, in addition to the wheels which run on the upper side of the girder, there are also two wheels on the under side, and that these are capable of a vertical movement in guides. When any strain is put upon the tow-rope it acts through the bell-cranks and presses the lower wheels against the under side of the girder, this pressure being proportional to the weight in tow of the tractor. It will be apparent, therefore, that the upper and lower wheels of the tractor are squeezed together on the girder when the load comes on, hence a relatively light tractor may be employed, and yet skidding avoided.

Fig. 4 shows the tractor mounted on the girder. The supply of current is through an overhead trolley wire; the controller, which is of the tramway type, is fixed at the foot of the pole, the handle being close to the operator's seat seen on the right. The motor, which is of 45 h.-p., is fixed at the bottom of the framework, the pinion gears into a spur wheel which gears into two other gear wheels, which are mounted on the same shaft as the driving wheels, the latter being 12 in. diameter.

Although this tractor weighs only three tons, it can exert a pull of one ton at 4½ miles per hour. The efficiency of the tractor when hauling four barges having an aggregate weight of 800 tons at three miles per hour, is estimated at 85 per cent.

**Electric Traction on Main Line Railways.***—Last month we reviewed the general question and the considerations which led to the choice of a single-phase system in

* In our notes on the Single-phase System of Electric Traction which appeared in our December issue, we referred to the paper by Mr. C. F. Scott of the General Electric Co., U.S.A. This gentleman is, however, with the Westinghouse Electric and Manufacturing Co., U.S.A.

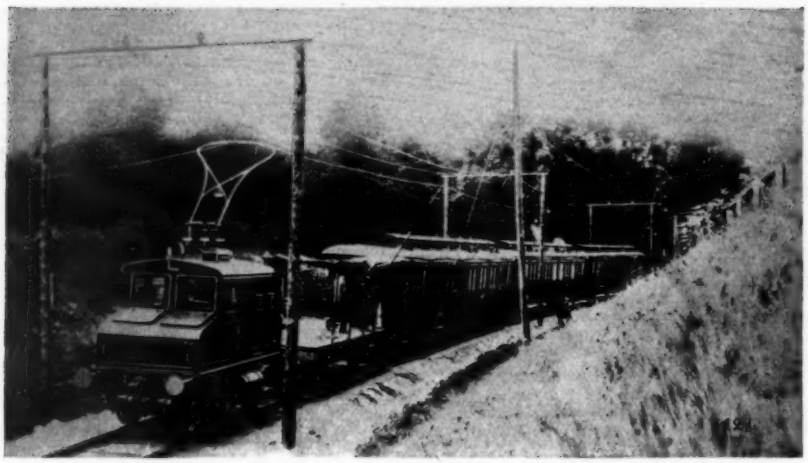


FIG. 5.—"WESTINGHOUSE" SINGLE-PHASE LOCOMOTIVE IN OPERATION ON THE SWEDISH STATE RAILWAYS.

preference to any other for experimental purposes on the Swedish State railways. The generating station now calls for a passing reference. It at present contains two 175 Kilowatt "De Laval" turbo-alternators, and provision is made so that by changing the speed periodicities, varying from 15 to 25 cycles per second, can be obtained.

The track extends to about 6¾ miles, three miles of which is still under construction. The trolley wire has a diameter of about 3 in., and is suspended at a height varying from 15 to 18 ft. from the rail level, and with a view to determining the most suitable method of suspension, several different methods have been used. Wood poles are used throughout, as plenty of timber is available, and the overhead structure is not subjected to severe strains. In this respect the bow trolleys are superior to the wheel trolleys common on British and American

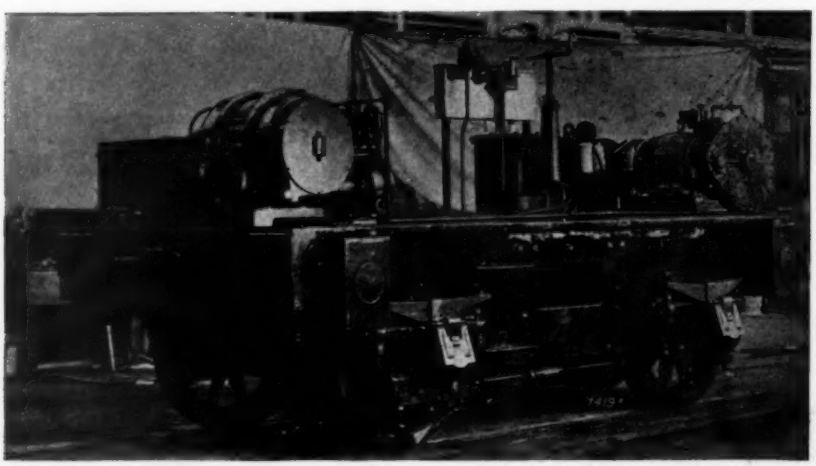


FIG. 6.—TRUCK OF "WESTINGHOUSE" SINGLE-PHASE LOCOMOTIVE.

FIG. 7.—MOTORS OF "WESTINGHOUSE" ELECTRIC LOCOMOTIVE.

tramways, though there are six poles of reinforced concrete used at sharp curves. The return current passes along the rails, which, however, are not bonded except for a very small part of the line, as experience may show this to be unnecessary, as even with the largest locomotives at present used, the current will only be about 100 amperes at 3,000 volts, and about 15 amperes at 20,000 volts. The rolling stock consists of two electric locomotives, one by the British Westinghouse Co., and one by the Siemens-Schuckert Werke, and two motor cars, built by the Nya Aktiebolaget Atlas Stockholm, and equipped with two Eichberg single-phase motors, by the Allgemeine Elektricitäts, Gesellschaft, Berlin. The first of these, viz., the "Westinghouse" electric locomotive, is illustrated (Fig. 5) at the head of a train. This locomotive is mounted on a four-wheel truck (Fig. 6), and has two 150 h.-p. single-phase motors, one geared to each axle by spur gear having a ratio of reduction of 3·89 to 1. These will be seen from Fig. 7, which shows the equipment after the truck frame has been removed. The wheelbase is 8½ ft. and the diameter of the driving-wheels 41 in. The locomotive is powerful enough to draw a 70-ton train at 40 miles per hour, and as a matter of fact has hauled 300-ton trains without difficulty. The normal draw bar pull is 9,500 lbs.

A feature in common with all the other locomotives and motor cars is the use of a transformer to reduce the line pressure to that suitable for the motors which differs somewhat with each equipment, but is from 120 to 330 volts, depending on the speed required and the views of the designer,

The control is electro-pneumatic, the master controller being seen in the centre of the truck (Fig. 6) along with the valves for the air-brake and the hand-brake. The apparatus at each end of the truck, which is located under the sloping frame at either end of the driver s cab, comprise an oil-cooled transformer for reducing the line pressure, an oil break circuit breaker for opening the line circuit, an air compressor driven by a single-phase motor, an induction regulator for varying the pressure supplied to the main motors, the regulator in question being controlled by a small compressed air motor. The circuit breaker, it should be noted, is also operated by compressed air, hence the driver scarcely handles directly any electrical apparatus. The air compressor also supplies the air brakes and air sanders. The total weight of the locomotive is 25 tons, and it is fitted with the standard buffers and couplings used on the Swedish railways, these having been fixed when the locomotive was delivered to the shops in Stockholm. A somewhat larger locomotive has been supplied by the Siemens-Schuckert Co. It weighs 36 tons, and is fitted with three motors each of 110 h.-p. This locomotive (Fig. 8) is intended primarily for goods traffic, and is therefore designed for a speed of 28 miles per hour on the level, though by altering the gear ratio, speeds of 40 miles per hour can be obtained. The body is 21 ft. long by 8 ft. 6 in. wide, and has the driver's cab at one end instead of in the centre as is the case with the "Westinghouse" locomotive already described. and the North-Eastern and Metropolitan Railways in this country. The box-shaped compartment seen behind the cab, and on the top of which the trolleys are mounted, contains the high tension leads and switches, while below is the transformer, the 7 h.-p. motor for the air brakes, and another 7 h.-p. motor which drives the oil pump for circulating oil through the transformer to keep it cool; this also drives a fan which

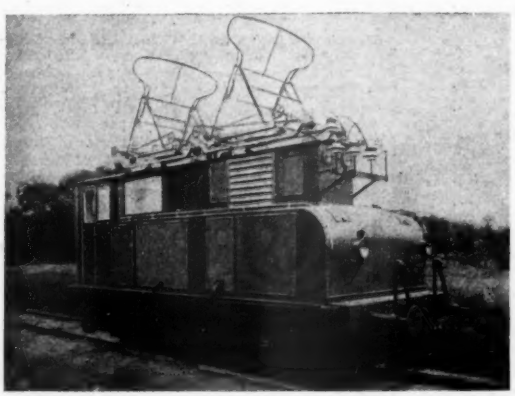


FIG 8.—"SIEMENS-SCHUCKERT" SINGLE-PHASE LOCOMOTIVE.

delivers about 1,400 cubic feet of air per minute at 3 in. water pressure, which passes through the main motors to keep them cool. In addition this motor drives another air compressor, which delivers air at about 85 lbs. per square inch for the whistle.

The three 110 h.-p. main motors (one on each axle) are geared by means of spur gear having a ratio of 5·1 to the driving-wheels, which have a diameter of 43½ in., the three motors exert a pull of 13,224 lbs. at the tread of the wheels.

Unlike the "Westinghouse" equipment, the controller, high tension oil switch, and reversing switches, are operated by hand, compressed air only being employed as already indicated for the brakes and whistle.

The high tension switch, though it can be opened at any time, cannot be closed unless the controller is on the "off" position. Two auxiliary connections are taken from the main transformer, one at 120 volts for lighting and heating the locomotive, and another at 240 volts for operating the auxiliary motors.

## Catalogues and Trade Notices.

**Sir W. G. Armstrong, Whitworth & Co., Ltd.,** Openshaw, Manchester. New and enlarged illustrated edition of their price list of Whitworth Standard Thread screwing apparatus. An interchangeable system has been introduced by which every stock is made to standard dimensions and gauges, and the dies for each stock are interchangeable in sets of three without regard to the particular stock.

**A. Warden & Co.,** 60, Great Eastern Street, E.C. From this firm we have received a four-page circular dealing with the "Lytestrong" pulley which appears to possess several features of interest. It is of the split type, and is constructed of pressed steel, by which the weight is reduced to about half that of a cast-iron pulley. The hub is of massive construction, and interlocks with the spider in a way which relieves the hub rivets of shearing strain. The rim rivets are similarly relieved, the power being transmitted from the spider to the rim by dowel plates, located between the arms engaging with the central rib of the rim. Interchangeable bushings enable the pulleys to be fitted to any shaft.

**Joshua Heap & Co., Ltd.,** Ashton-under-Lyne. New 1906 catalogue of screwing machines. engineers', plumbers', and gas and steam fitters' tools. This catalogue is well got up, and does the firm great credit. Many improvements in design have been effected since the issue of last catalogue, and these machines have been re-photographed and are illustrated by first-class process blocks, and a number of new machines are also included. Many machines are now arranged for motor drive which can also be supplied by the firm.

**Ed. Bennis & Co., Ltd.,** Bolton. Reprint of a lecture by Mr. A. W. Bennis, M.I.Mech.E., entitled, "Is Machine Stoking Economical?" Any of our readers will be supplied with a copy on application to Bolton on mentioning this journal.

**Meldrum Bros., Ltd.,** Timperley, near Manchester, have been awarded the silver medal for their refuse destructor at the recent Smoke Abatement Exhibition.

**Kennicott Water Softening Co.,** 29, Great St. Helen's, have sold a 15,000 gallon per hour type "A" Kennicott water softener and purifier to the Upper Forest and Worcester Steel and Tinplate Works, Ltd., of Morriston, Glamorganshire.

**J. A. Ballantyne,** 212, Bath Street, Glasgow. Card showing a diagram of Ballantyne's improved stud screws for use in fixing electric fittings, name plates, finger plates, and other articles, where ordinary round-headed screws are unsightly.

**Electromotors, Ltd.,** Openshaw, Manchester. Copy of latest catalogue and novelty issued by this firm. The former deals with their continuous current motors and dynamos, both enclosed and semi-enclosed, motor starting rheostats, spur reduction gears, &c. The latter is called the "Motorgraphe," and the use of which is to determine the necessary size of motor for any given conditions of horse-power and speed.

**Tangye Tool and Electric Co., Ltd.,** Birmingham. Catalogue No. 59, dealing with T. T. E. high-speed lathes made from entirely new designs and patterns after an exhaustive series of experiments in "high-speed" steel tools.

**Simplex Steel Conduit Co., Ltd.,** Birmingham. Pocket list, giving details of the latest additions to this system together with prices of ordinary and screwed material in a condensed form.

**The Diesel Engine Co., Ltd.,** 179, Queen Victoria Street, E.C. 2nd edition of "The Little Red Book" containing much useful information concerning the "Diesel" engine.

**Thos. Piggot & Co., Ltd.,** Spring Hill, Birmingham. Circular re welded pipes, giving condensed information as to this portion of the firm's business.

**Pulsometer Engineering Co., Ltd.,** Reading. Abridged catalogue of pumps, pump fittings, ice making and cooling plant, water softeners, &c.

**Gibbons, Bros., Ltd.,** Dibdale Works, Dudley. Booklet relating to further improvements in the design of band conveyers as manufactured by this firm.

**List of Publications the principal contents of which are regularly indexed.**

American Engineer and Railroad Journal, 140, *Nassau Street, New York* ... ... ... 20 cts.
American Machinist, 218, *William Street, New York* ... ... ... ... ... 4d.
Annales de l'Association des Ingenieurs sortie de Gand, *Rue Longue du Marais, 15, Ghent*... 2 frs. 30 c.
Australian Mining Standard, 31, *Queen Street, Melbourne* ... ... ... ... 6d
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British Clayworker, 43, *Essex Street, W.C.* ... 6d.
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Canadian Engineer, 62, *Church Street, Toronto* 10 cts.
Cassier's Magazine, *New York* ... ... ... 1/-
Centralblatt für Accumulatoren, *Gross Lichterfelde-West, Bellevuestrasse, 40, Berlin* ... 3 mks. 50 pf. per qt.
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Compte Rendu des Travaux de la Société des Ingenieures Civils de France, 9, *Rue Blanche, Paris* ... ... ... ... ... —

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Dingler's Polytechnic Journal, *Berlin* .. ... 3 mos. / 6 mrks.

L'Echo des Mines et de la Metallurgie, *Paris*... 45 fr. p.a.
L'Eclairage Electrique, 40, *Rue des Ecoles, Paris* ... ... .. ... ... ... 1 fr. 50 c.
Electrical Engineer, 139, *Salisbury Court, E.C.* 3d.
Electrical Review, 4, *Ludgate Hill, E.C.* ... 6d.
Electrical Review, N.Y., 41, *Park Row, New York, U.S.A.* ... ... ... ... ... 10 cts.
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## Civil Engineering.

Trunnion Bridge for W. and L. E. R. R. at Cleveland. *Railway and Engineering Review, 16th December*, 1905.

The Triangulation and Construction Survey for the Simplon Tunnel. *Engineering News, 21st December*, 1905.

Tunnel Construction on Salt River, Reclamation Project, Arizona. *Engineering Review, 16th December*, 1905.

The new Steel Arch Street Bridge across the Potomac River, Washington, D.C. *Engineering News, 21st December*, 1905.

A Summary of Panama Canal, Plans and Arguments, III. *Engineering News, 14th December*, 1905.

Upper Sections of the Manhattan Bridge Towers. *Engineering Record, 2nd December*, 1905.

The Changes at the New Croton Dam. *Proc Am. Soc. Civil Engineers, December*, 1905.

The New York State Barge Canal. *Railway Gazette, 29th December*, 1905.

The Construction of a Reinforced Concrete Reservoir at Fort Meade, South Dakota. *Engineering News, 28th December*, 1905.

Masonry Barrages and Reservoir Walls. *La Houille Blanche, December*, 1905.

The Protecting Gallery at the Mythenshein Tunnel. *Beton u Eisen, December*, 1905.

A Temporary Bridge with Pontoon Draw Span over the Chicago River. *Engineering News, 28th December*, 1905.

The Reconstruction of the Moncreiffe Tunnel. *Engineering Record, 9th December*, 1905.

Williamsburg Bridge, New York. *Engineering. 15th* and *29th December*, 1905.

Tests of the Cavite Steel Floating Dry Dock. *Engineering News, 7th December*, 1905.

A Review of the Engineering Proposals for the Panama Canal. *Engineering News, 7th December*, 1905.

Lawrence Street Bridge, Denver. *Engineering Record, 2nd December*, 1905.

Rapid Transit Subway Construction on Fulton Street, Brooklyn, I., II. *Engineering Record, 23rd* and *30th December*, 1905.

The Grand River Ontario Peninsula, Effect of Deforestation and Swamp Drainage. *Proceedings Canadian Society Civil Engineers, December*, 1905.

Proposed New Cut in the Scheldt. *Annales de l'Assoc. des Ingrs. Sortis des Ecoles de Gand*, 1905, Vol. iv., No. 1.

Calculating the Wall Thickness of Circular Tunnels. *La Houille Blanche, December*, 1905.

## Building.

Steel Work of the Ash Plant of the New York Edison Co. *Engineering Record*, 9th *December*, 1905.

Reinforced Concrete and Tile Construction in an Atlantic City Hotel, I., II. *Engineering Record*, 23rd and 30th *December*, 1905.

The Economical Design of Reinforced Concrete-Floor Systems for Fire-Resisting Structures. *Proceedings American Society Civil Engineers*, *December*, 1905.

Reinforced Concrete Pile Foundation for the Lattemann Building, Brooklyn, New York. *Engineering News*, 7th *December*, 1905.

The Orientation of Buildings and of Streets in relation to Sunlight. *Technology Quarterly*, *September*, 1905.

The Union Engineering Building at New York City. *Railway and Engineering Review*, 16th *December*, 1905.

The Simplex System of Concrete Piling. *Proceedings Engineers' Club of Philadelphia*, *October*, 1905.

The Safeguarding of Life in Theatres, a Study from the Standpoint of an Engineer. *Engineering News*, 14th *December*, 1905.

## Heating and Ventilation.

The Heat Unit and its Application to the Heating of Buildings. *Engineer*, *Chicago*, 1st *December*, 1905.

## Materials and Measurements.

The Action of Sea-water upon Concrete. *Engineering*, 5th *January*, 1906.

Decay of Stones in Buildings: the Cause and Prevention. *Proceedings Philosophical Society*, *Glasgow*, 1904—5.

The Microscopic Structure of Building Stones. *Proceedings Engineers' Club of Philadelphia*, *October*, 1905.

Pressure Tests on Wire-bound Concrete. *Beton und Eisen*, *December*, 1905.

Shear and Adhesion in Reinforced Concrete. *Engineering*, 5th *January*, 1906.

The Bursting Strength of Reinforced Concrete Pipes. *Engineering Record*, 9th *December*, 1905.

Internal Longitudinal Strains in Simple Cement and Concrete Bodies. *Beton und Eisen*, *December*, 1905.

Percussion Bending Tests on Clamped Bars. *Zeitsch. des Oesterr. Ingr. u. Arch. Ver.* 22nd *December*, 1905.

## Boilers, Furnaces and Fuel.

Smoke Abatement Conference. *Gas World*, 16th *December*, 1905.

Test of a Rotary Kiln. *Engineering Record*, 2nd *December*, 1905.

Materials of Boilers. *Engineer*, *Chicago*, 1st *December*, 1905.

Experiments with the Pitot Tube in Measuring the Velocities of Gases in Pipes. *Engineering News*, 21st *December*, 1905.

Elasticity of Boiler Flues with widely spaced Corrugations. *Zeitsch. des Vereines Deutscher Ingr.*, 23rd *December*, 1905.

Trials and Investigations with Reversed Draught Gas Generators. *Memoires Society des Ingrs. Civi de France*, *October*, 1905.

Coke as a Blast Furnace Fuel. *Steven's Institute Indicator*, Vol. xxii., No. 4.

## Engines and Motors.

Pressures at the various Stages of Multiple-Stage Steam Turbines. *Power*, *December*, 1905.

Notes on the Design of Reaction Turbines. *Power*, *December*, 1905.

The Slip of Discharge Valves. *Practical Engineer*, 15th *December*, 1905.

Design, Construction, and Application of Large Gas Engines in Europe, II. *Power*, *December*, 1905.

Governor Springs. *Practical Engineer*, 29th *December*, 1905.

High-Speed Outflow of Steam and Gases. *Engineer*, 22nd and 29th *December*, 1905.

Electric Ignition for Gas Engines, I. *Mechanical World*, 5th *January*, 1906.

German Turbines at Niagara. *Zeitsch. des Ver. Deutscher Ingr.*, 16th *December*, 1905.

Pressure Ratios and Thrust in the Francis Turbine. *Zeitsch. des Oesterr. Ingr. u. Arch. Vereines*, 8th *December*, 1905,

The Steam Consumption of Piston Engines. *Power*, *December*, 1905.

Tests of De Laval Steam Turbine. *Engineer*, 29th *December*, 1905.

The Oechelhouser Gas Engine. *Engineer*, 5th *January*, 1906.

Allis-Chalmers Steam Turbine. *Western Electrician*, 16th *December*, 1905.

Test of a 500-kilowatt "Curtis" Steam Turbine at Ottumwa, Iowa. *Engineer*, *Chicago*, 1st *December*, 1905.

The Meaning of Adiabatic. *Engineer*, 15th *December*, 1905.

The first Steam Engines outside England. *Zeitsch. des Ver. Deutscher Ingr.*, 9th *December*, 1905.

Steam Turbine Plant at the Saarbrucken Railway Station. *Zeitsch. des Ver. Deutscher Ingr.*, 16th *December*, 1905.

Multiple-Stage Steam Turbines. *Zeitsch. des Oesterr. Ingr. u. Arch. Ver.*, 29th *December*, 1905.

## Hydraulics and Compressed Air.

High Pressure Steam-pipe Flanges. *Power*, *December*, 1905.

Test of a Three-Stage, Direct Connected, Centrifugal Pumping Unit. *Proc. Am. Soc. Civil Engineers*, *December*, 1905.

A New Method of Pumping Sand by means of Compressed Air at the Plant of the United States Silica Co. *Engineering News*, 7th *December*, 1905.

Hydraulic Station at Cusset, near Lyons, France. *Electrical World and Engineer, 9th December*, 1905.

Water Power Plants: Common Troubles, Causes, and Remedies. *Power, December*, 1905.

## Shop Equipment and Practice.

Cone Pulley Design. *American Machinist, 30th December*, 1905.

Machine Shop Practice. *Mechanical World, 15th December*, 1905.

Turret Attachment for Lathe. *Mechanical World, 5th January*, 1906.

Machine Shop Practice. *Proc. Engineers' Society, W. Pennsylvania, November*, 1905.

54 in. Rapid Production Boring and Turning Mill. *American Engineer and Railroad Journal, December*, 1905.

Gear Box Drives, *American Machinist, 30th December*, 1905.

Lathe for High-Speed Steel. *Engineering, 5th January*, 1906.

A 600,000 lb. Screw-Testing Machine. *American Machinist, 6th January*, 1906.

54-in. Rapid Production Boring and Turning Mill. *American Machinist, 16th December*, 1905.

Multiple Drill for Water Tube Boiler Work. *Engineering, 22nd December*, 1905.

Machine Tools at the Liége Exhibition. *Zeitsch. des Ver. Deutscher Ingr., 16th December*, 1905.

## Miscellaneous Mechanical Subjects.

A Diagram for Computing the Power Capacity of Belts. *Mechanical World, 15th December*, 1905.

Mechanical Plant of the New 23rd St. Terry Terminals, New York. *Engineering Record, 2nd December*, 1905.

The Mechanical Plant of the Hotel Belmont, New York City, I. *Engineering Record, 30th December*, 1905.

Fans, III. *Machinery, December*, 1905.

Bearings. *Proc. Engineers' Society, W. Pennsylvania, December*, 1905.

Tests of the Plunger Elevator Plant in the Trinity Building, New York City. *Engineering News, 14th December*, 1905.

Anchor and Chain Cable Tester. *Zeitsch. des Ver. Deutscher Ingr., 23rd December*, 1905.

Drying Plant. *Zeitsch. des Ver. Deutscher Ingr., 23rd December*, 1905.

Centrifugal Fans. *Proc. Engineers' Society, W. Pennsylvania, November*, 1905.

Methods and Cost of Trench Excavation with a Trench Digging Machine. *Engineering Record, 30th December*, 1905.

Notes on Belt and Rope Drives. *Engineer, 22nd December*, 1905.

The Resistance of Tubes to Collapse. *Physical Review, December*, 1905.

Belt Transmission of Power as an Analogue of Electric Transmission. *Electrical World and Engineer, 9th December*, 1905.

Contribution to the Theory of the Wire Rope. *Zeitsch. des Oesterr. Ingr. u. Arch. Vereines, 15th December*, 1905.

## Railway and Locomotive Engineering.

Pacific Balanced Compound for the Santa Fé. *Railway Age, 8th December*, 1905.

Gasolene Motor Car, Union Pacific Railway. *Engineering News, 21st December*, 1905.

Baltimore and Ohio Consolidation Locomotive. *Railway Age, 22nd December*, 1905.

Four-Cylinder Compound Locomotive, Eastern Railway of France. *Engineering, 22nd December*, 1905.

The Origin of Four-Cylinder Balanced Compound Locomotives. *Railway Gazette, 22nd December*, 1905.

Locomotive Injectors, Modern Practice. *Railway Age, 29th December*, 1905.

Radial Tank Engine, North Staffordshire Railway. *Engineer, 15th December*, 1905.

Vauclain Four-Cylinder Balanced Compound Passenger Locomotive, Pacific Type. *American Engineer and Railroad Journal, December*, 1905.

New Locomotive Types on the Austrian State Railways. *Die Lokomotive, December*, 1905.

Six-Coupled Express Locomotive, Glasgow and South-Western Railway. *Engineer, 29th December*, 1905.

Combination Draft Carrier and Body Bolster. *Railway Age, 22nd December*, 1905.

Ten-Wheeled (4—6—0) Locomotive for the New York Central and Hudson River. *Railway Gazette, 29th December*, 1905.

The Lackawanna Eight-Wheel Passenger Locomotive with Superheater. *Railway Age, 15th December*, 1905.

Locomotive Cylinders. *American Engineer and Railroad Journal, January*, 1906.

Walschaert Valve Gear. *American Engineer and Railroad Journal, January*, 1906.

German Compound Locomotive with Superheater. *Railway Age, 1st December*, 1905.

Ten-Wheel Locomotive, N. Y. C. and H. R. R. R. *Railway and Engineering Review, 2nd December*, 1905.

Electric *v.* Steam Locomotives. *Engineer, Chicago, 1st December*, 1905.

New Carriage and Wagon Works, Great Central Railway. *Engineer, 29th December*, 1905.

Reconstruction of Haydon Square Goods Depot London and North-Western Railway. *Railway Engineer, January*, 1906.

Classification of Locomotives for Tonnage Rating Purposes. *American Engineer and Railroad Journal, December*, 1905.

The Stubaithal Railway. *Elek. Bahnen u Betriebe, 14th December*, 1905.

The Euston to Camden Widening. *Railway Gazette, 15th December*, 1905.

Locomotive Testing Plant at Swindon. *Engineer*, 22*nd December*, 1905.

The Measurement of Vibrations of Railway Cars. *Railway Age*, 29*th December*, 1905.

## Automobilism and Road Traction.

The Richard-Brassier Car of 1906. *Autocar*, 6*th January*, 1906.

The 14 h.-p. 1906 Star Car. *Autocar*, 16*th December*, 1905.

The 20 h.-p. Rolls-Royce Tourist Trophy Car. *Autocar*, 23*rd December*, 1905.

The New Arrol-Johnston Petrol Cars, V., VI. 16*th* and 23*rd December*, 1905.

Tests relating to Bearing Lubrication. *Autocar*, 30*th December*, 1905.

A Power Indicator. *Autocar*, 23*rd December*, 1905.

The Franklin Air-Cooled Engines. *Autocar*, 30*th December*, 1905.

Baggage Car for Automobiles. *American Engineer and Railroad Journal*, *December*, 1905.

## Electric Lighting.

An efficiency meter for Electric Incandescent Lamps. *Electrical World and Engineer*, 2*nd December*, 1905.

Regulation and Compounding of Lighting Balancers. *Electrical World and Engineer*, 23*rd December*, 1905.

## Electrical Generation and Transmission.

Zambesi Power Scheme. *Electrical Review*, 15*th December*, 1905.

Economical Loss in Electric Transmission. *American Engineer and Railroad Journal*, *January*, 1906.

Hydro-Electric Power under the highest Head in New England. *Electrical World and Engineer*, 2*nd December*, 1905.

Electric Motors and their Applications. *Proc. Engineers' Soc. W. Pennsylvania*, *October*, 1905.

Some New Inter-pole Variable Speed Motors. *Railway Gazette*, 29*th December*, 1905.

Electrical Generating and Storage Plant at Ruppoldingen. *Zeitsch. fur Elektrotechnik*, 17*th December*, 1905.

The Bow Generating Station of the Charing Cross and City Co. *Electrical Review*, 15*th December*, 1905.

Starting Alternating-current Motors at Full Torque. *Western Electrician*, 16*th December*, 1905.

Power Supply by the L.C.C. *Engineering*, 15*th December*, 1905.

The Ferranti-Field Three-phase Switch. *Engineering*, 5*th January*, 1906.

The Overload and Reverse Current Relay. *Electrical Review*, 29*th December*, 1905.

Capacity of Accumulators per Unit of Weight. *Centralblatt fur Accumulatoren-Technik*, 1*st December*, 1905.

## Electric Traction.

Falkirk Electric Tramways. *Tramway and Railway World*, 7*th December*, 1905.

Electrification of the Long Island Railway. *Engineer*, 29*th December*, 1905.

Electrification of the Paris-Orleans Surburban Line. *Engineering*, 5*th January*, 1906.

G.-B. Surface Contact at Lincoln. *Electrical Times*, 4*th January*, 1906.

The Neuchatel Electric Tramways. *Electricity*, *New York*, 27*th December*, 1905.

Electrification of the New York City Terminals of the New York Central R. R. *Railway Age and Engineering Review*, 9*th December*, 1905.

Electric Tramways in Singapore. *Tram and Railway World*, 7*th December*, 1905.

The Wear of Tram Rails. *Engineer*, 22*nd December*, 1905.

The Pennsylvania Railroad Low Grade Freight Line from Harrisburg to Atglen, Pa. *Engineering News*, 28*th December*, 1905.

The Ventilation of the Baker-Street and Waterloo Railway, *Engineering*, 22*nd December*, 1905.

Safety Appliances for High-tension Electric Conduits. *La Houille Blanche*, *December*, 1905.

## Miscellaneous Electrical Subjects.

Electric Furnaces. *Electricity*, 22*nd December*, 1905.

Four-ton Single-phase Electric Travelling Wharf Crane at Cologne. *Engineering*, 22*nd December*, 1905.

Electricity direct from the Coal Mine at Radcliff. *Electrical World and Engineer*, 23*rd December*, 1905.

Novel Electric Water Hoist. *Western Electrician*, 2*nd December*, 1905.

Electrolysis by Alternating Currents. *Engineering*, 5*th January*, 1906.

Zinc and Aluminium Fuses. *Electrical Review*, 5*th January*, 1905.

The Practical Application of the Heyland Diagram for Induction Motors. *Electrical World and Engineer*, 23*rd December*, 1905.

The Measurement of High Frequency Currents and Electric Waves, I., II. *Journal Society Art*, 29*th December*, 1905, and 5*th January*, 1906.

The Approximate Calculation of Plunger Electromagnets. *Electrical World and Engineer*, 16*th December*, 1905.

Developments in Electric Signalling during the Nineteenth Century. *Proc. Royal Philosophical Society, Glasgow*, 1904—1905.

### Marine Engineering and Naval Architecture.

Problems in connection with High-speed Launches. *The Steamship, January*, 1906.

Gunboat for the Brazilian Government. *Engineer*, 29*th December*, 1905.

H.M. Fleet Scout *Attentive*. *Engineer*, 22*nd December*, 1905.

Shipbuilding and Marine Engineering in 1905. *Engineering*, 5*th January*, 1906.

The Sea-going Battleship, *Technology Quarterly, September*, 1905.

The Determination of the Principal Dimensions of the Steam Turbine with special reference to Marine Work. *Discussion Trans. Inst. Engineers and Shipbuilders, October*, 1905.

Air Pumps for Marine Engines. *Zeitsch. des Ver. Deutscher Ingr., 2nd December*, 1905.

### Water Supply.

The Reconstruction of the Poughkeepsie Water Filters. *Engineering Record, 2nd December*, 1905.

Four Varieties of Water Pressure Regulating Valves. *Engineering News*, 28*th December*, 1905.

### Sewage.

Development of Sanitary Science. *Proceedings Royal Philosophical Society, Glasgow*, 1904—1905.

The Sewage Purification Works at Columbus, Ohio. *Engineering Record*, 30*th December*, 1905.

Sewage Disposal at Berlin, Ontario. *Engineering Record*, 23*rd December*, 1905.

Sewer Construction in Brooklyn. *Engineering Record, 2nd December*, 1905.

Electricity and Sewage Disposal. *Electrical World and Engineer*, 16*th December*, 1905.

### Streets and Pavements.

An Asphalt Plant for Walks and Crossings in Small Cities. *Proceedings Canadian Society Civil Engineers, December*, 1905.

### Engineering Economics and Works Management.

### Miscellaneous.

The Testing of Explosives used in Engineering. *Proceedings Canadian Society Civil Engineers, November*, 1905.

A New Form of Procedure for Earthwork Computations, and a Slide Rule therefor. *Engineering News*, 21*st December*, 1905.

High-Speed Steel. *Engineering*, 15*th December*, 1905.

The Future Rôle and Organization of our Siege Artillery in War. *Journal of the Royal Artillery, December*, 1905.

Graphostatical Examination of the Flattened Parabolic Arch. *Zeitsch. des Osterr. Ingr. u. Arch. Vereines, 22nd December*, 1905.

The Real Want and Commercial Value of Patented Inventions. *Steven's Institute Indicator*, Vol. xxii., No. 4.

Gold Mining in Japan. *Proceedings Institute Mining and Metallurgy, December*, 1905.

Notes of some Recent Experiments on the Magnetic Concentration of Iron Sands from the Lower St. Lawrence. *Proceedings Canadian Society Civil Engineers, November*, 1905.

Notes on the Method of Designing Projectiles. *Journal Royal Artillery, December*, 1905.

Note on a New Instrument for Surveying Deep Bore Holes. *Proceedings Canadian Society Civil Engineers, November*, 1905.

Some Surveying Instruments. *Engineer*, 15*th December*, 1905.

Laboratory Courses in Engineering Schools. *Steven's Institute Indicator*, Vol. xxii., No. 4.

The Chemical Analysis of Dynamites. *Steven's Institute Indicator*, Vol. xxii., No. 4.

## Calendars Received.

**R. Y. Pickering & Co.,** Wishaw. N.B. Tear off calendar, showing a month at a time in clear figures, easily read at a distance.

**W. T. Glover & Co., Ltd.,** Trafford Park, Manchester. Block calendar with extracts from the technical press, interspersed with a little lighter reading. All data this year concerning Glover's specialities has been relegated to the back of the card. Also a novel pipe cleaner, with Glover's trade mark, as a handle.

**Consolidated Pneumatic Tool Co., Ltd.** Usual monthly calendar on card bearing half-tone embossed illustrations of some of the specialities of this firm.

**Mavor and Coulson, Ltd.,** Glasgow. Wall calendar bearing illustrations of their direct current coal-cutter.

**John I. Thornycroft & Co., Ltd.,** Chiswick. W. Wall calendar with design introducing their various specialities.

**Alex. Turnbull & Co., Ltd.,** Bishopbriggs, Glasgow. Wall sheet illustrated with the various specialities of this firm's patent safety valves, &c., with short description of each.

**Hunslet Engine Co., Ltd.,** Leeds. Wall calendar with card, covered in special washable gelatine for cleaning and polishing.